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The primary goal of the Acquisition Review Quarterly (ARQ) is to provide practicing acquisition professionals with relevant management tools and information based on recent advances in policy, management theory, and research. ARQ addresses the needs of professionals across the full spectrum of defense acquisition, and is intended to serve as a mechanism for fostering and disseminating scholarly research on acquisition issues, for exchanging opinions, for communicating policy decisions, and for maintaining a high level awareness regarding acquisition management philosophies.

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TUTORIAL

AN ANALYSIS OF MANAGEMENT RESERVE BUDGET ON DEFENSE ACQUISITION CONTRACTS

David Christensen, Ph.D. and Carl Templin, Ph.D.

How should one determine the amount required for a contract's management reserve budget? This study reviews decades of data and provides benchmarks for establishing an appropriate amount for such a budget, as well as insight into the relative risk across contract categories, acquisition phases, and contracts managed by the services.

A management reserve (MR) budget is an amount of the total allocated budget (TAB) withheld by contractors for management control purposes. More specifically, its purpose is to provide an adequate budget for in-scope but unanticipated work on the contract. As a contract proceeds to completion, and unanticipated, in-scope work is identified, an MR budget is allocated to that work. Once allocated, an MR budget becomes part of the performance measurement baseline (PMB) used to measure and control cost and schedule performance on the contract. Accordingly, an MR budget is an important part of effective planning and control on defense contracts.

Presumably, contracts with greater risk (uncertainty) will have a need for a greater MR budget. Using data from the Defense Acquisition Executive Summary (DAES) database, we test this assumption. In addition, we provide quarterly descriptive statistics and related graphics on the amount and use of an MR budget on hundreds of defense acquisition contracts from 1975 to 1998. Results indicate statistically significant differences in the median MR budget percentage across contract categories (cost-reimbursable and fixed-price) and the military services managing the contracts (Army, Air Force, Navy), and no significant differences across acquisition phases (development and production).

Purposes of an MR Budget

Budgets, including MR budgets, have many purposes, including planning, communication, coordination, control, motivation, and performance evaluation. A budget that is optimal for one purpose may not be optimal for another (Barrett and Fraser, 1977). For example, for planning and control purposes, budgets should be accurate estimates of future costs. But for other purposes, budgets may be deliberately overstated by a manager to minimize the need for variance reporting, or deliberately understated by a manager's supervisor to reduce possible over consumption of resources (Merchant, 1985, Merchant and Shields, 1993, Merchant and Manzoni, 1989).

Uncertainty

As indicated in Department of Defense (DoD) policy documents, the primary purpose of an MR budget is a reserve for uncertainties related to in-scope but unforeseen work (DoD, 1997, p. 12):

> In most projects, particularly developmental activities, there is considerable uncertainty regarding the timing or magnitude of future difficulties. The use of MR provides the project manager with a capability to adjust for these uncertainties.

Examples include work created by events that cannot be predicted, such as accidents, planning errors, technical redirections, or contractor-initiated studies.

Budgets for all authorized work should be included in the performance measurement baseline (PMB). Work without budget or budget without work is inappropriate for performance measurement and control purposes. Work without budget overstates the cost variance. Budget without work understates the cost variance. In either case, effective control via variance analysis is impaired.

Motivation

The earned value literature suggests that another purpose of an MR budget is motivational: to create a "budget challenge" for control account managers (e.g., Antolini, et al., 1991, p. 31; Bowman, 1993, p. 5; Fleming, 1992, p. 49; Gould, 1995, pp. 29–31). Two relatively new forms of challenge budgeting are target costing and *kaizen* budgeting. Both were popularized in Japan but are now found worldwide (Tanaka, 1993).

Target costing is a process of determining a maximum allowable cost for a product by subtracting a desired profit from the product's market price. Value engineering is then used to design the product to stay within the target cost. Target costing applies primarily to the design phase, where the majority of a product's lifecycle costs is determined (Artto, 1994).

Cost as an independent variable (CAIV) is the DoD analogue of target costing. Lacking market prices, the target cost under CAIV comes from an "affordability analysis" by the military services rather than from a market analysis. There is some evidence that CAIV has been effective in controlling the cost of recent defense acquisition projects (e.g., Coleman et al., 1998).

Kaizen budgeting occurs during the manufacturing stage of a product, and may be viewed as a final step in the target costing process (Blocher, Chen, and Lin,

1999, p. 138). Kaizen budgeting is intended to stimulate innovation and process improvements that lead to cost reduction. "Kaizen" is a Japanese term for continuous improvement. Kaizen budgeting explicitly anticipates continuous improvements in operating processes. Instead of assuming that current practices will continue, a kaizen budget is viewed as a challenge to managers to alter practices in ways that reduce costs without reducing quality.

Estimating an MR Budget

Estimating the amount of an MR budget may appear to be an oxymoron: How can something that is unforeseen be estimated? However, Antolini et al. (1991, p. 32) report that most contractors can determine an MR budget from their own experience with prior contracts. In addition, before contract award, prudent managers almost certainly include an unspecified amount of excess budget in their cost estimates. Research suggests that:

- Budgetary slack exists in most business organizations.
- It is in managers' best interests as rational economic individuals to create slack.
- It is nearly impossible to prevent (Bart, 1988, p. 188; Merchant, 1998, p. 219).

Although contractor policy may preclude managers from padding their budgets, it seems likely that every prudent manager would do so, knowing that only a fraction would be approved (Fleming, 1996, pp. 64–65). It is possible that an MR budget could be estimated by each manager and aggregated to the total program level with full visibility. However, based on a review of contractor system descriptions and telephone interviews with industry experts, Gould (1995, p. 38) reports that a "top-down" process is more common, where the contractor program manager withholds a portion of the approved contract budget base (CBB) as an MR budget.

Factors Affecting an MR Budget

Surveys of defense contractors (National Security Industrial Agency [NSIA], 1980; Gould, 1995) indicate that the amount of an MR budget depends on many factors, such as risk, management philosophy, the magnitude of the profit or fee, constraints related to time and experience, negotiation skills, and the stability of the contract requirements. In response to Gould's question of what factors influence the determination of an MR budget, one expert reports the following (Gould, 1995, p. 36):

"Kaizen budgeting explicitly anticipates continuous improvements in operating processes."

> The determination is entirely up to the contractor. In arriving at the proper amount of an MR budget, evaluation of the major risks is surely a prime factor. The degree to which the contractor wants motivational or incentivized budgets is another important factor.

> In assessing the risks, the near-term clearly defined work probably will be less risky than the far-term ill-defined or undefined work. Also, work which is the same or very similar to work which has been done previously will have less uncertainty (and impel less management reserve) than work which is not familiar.

With these factors in mind, determining the amount of an MR budget is probably best described as an iterative process, where all managers affected by an MR budget have some role in its determination (Slemaker, 1985, pp. 99–100).

> Regardless of the detail available, these budgets [MR, PMB, cost account budgets, and functional budgets] should be considered preliminary until functional and operating managers have accepted them....Managers who disagree with either the statement of work or the budget must make this known to their superiors as well as the project manager. Negotiations should take place.

Encouraging managers at all levels to participate in the budget process can improve the accuracy of the budget and management commitment to it (Garrison and Noreen, 2000, p. 382). Survey research shows that most companies use some form of participative budgeting (Horngren, Foster, and Datar, 2000, p. 181).

Uncertainty Analysis

Some authors suggest that an MR budget may be identified by uncertainty analysis, where the cost of each work breakdown structure (WBS) element is modeled as a random variable (e.g., Garvey, 1995, p. 161; Goldberg and Weber, 1998, p. III-17; Stewart and Wyskida, 1987, pp. 297–306). Instead of specifying a percentage of the CBB as the MR budget, the authors suggest specifying a probability for the cost of work (e.g., total project, control account) to be less than or equal to its budget, termed the "probability of success," P(s), in Goldberg and Weber (1998). Adding MR budget increases P(s). Thus, the amount of an MR budget can be identified at any desired P(s) specified by project management.

Determining an appropriate level for P(s) is unclear. Based on data gathered from 54 profit center managers in 12 corporations, Merchant (1989) indicates that most profit center managers prefer budgets that are achievable 80 to 90 percent of the time. However, control accounts are cost centers, not profit centers, and it is unknown if control account budgets are planned to be achievable at similar percentiles. In addition, Barrett and Fraser (1977, p. 137) suggest that budgets should be highly achievable for motivational purposes, and less achievable for planning and control purposes.

Several models have been developed to quantify project risk in support of estimating and budgeting. The risk analysis and cost management model (RACM) developed by Lockheed Martin is a recent example. In evaluating RACM, Goldberg and Weber (1998, p. III-6) note that summing budgets that are relatively easy to achieve ($P(s) > 0.5$) results in a budget for the entire project that is even easier to achieve:

The program-wide percentile will exceed the common WBS-element percentile when the latter is greater than .5; the opposite condition holds when the common WBS-element percentile is less than one-half.

Overall, this conclusion suggests that the achievability of a budget depends on how the budgets are established. Establishing challenge budgets for each control account at a specified P(s) will result in a challenge budget for the project with a different P(s). Likewise, removing an MR budget from the CBB at the project level for a specific P(s) will result in a different P(s) for each control account.

Since determining the PMB and the MR budget is almost certainly iterative, the ability to specify an appropriate amount of the MR budget using such models is unclear. Moreover, implementing probabilistic budgeting requires strong assumptions about the costs of WBS elements (e.g., distribution properties, correlation). For example, Goldberg and Weber (1998, p. I-7) report that RACM assumes normality, does not fully account for potential correlation among cost elements, and makes assumptions about contractor behavior that are not universally held. Other models make similar assumptions. In their review of RACM and similar models, Goldberg and Weber conclude that "neither RACM nor any other particular tool can be viewed as a silver bullet to remove all risk or prevent all cost overruns on defense programs" (1998, p. I-10). At best, RACM and similar models are decision support tools that make the treatment of risk more systematic; they do not replace management judgment.

Estimating an MR budget is necessarily a subjective process, involving negotiations among managers at various levels in the contractor organization. Budgets have several overlapping functions, including planning, motivation, and performance evaluation. Although budget theorists suggest that no single budget may be right for all purposes (Barrett and Fraser, 1977, p. 141), having a different budget for each purpose is uncommon (Umpathy, 1987). An MR budget reflects compromises between these purposes and the managers involved with it.

Historical data on the amount of MR budgets are available on a large number of completed and ongoing defense projects. The remaining sections of this article describe the amount of an MR budget established on defense acquisition contracts over the last two decades. Descriptive statistics may be useful as potential benchmarks for determining MR budget on new projects. In addition, we test for significant differences across acquisition phase (development versus production), contract category (cost-reimbursable versus fixed-price), and the military services managing the contracts. If an MR budget is indeed a function of management philosophy and uncertainty or risk, then differences may exist across these categories.

"Descriptive statistics may be useful as potential benchmarks for determining MR budget on new projects."

Methodology

Hypotheses

Because one of the stated purposes of an MR budget is to adjust for uncertainty related to the timing and magnitude of future difficulties, there should be a larger MR budget on projects with more uncertainty (risk).[1] Accordingly, the development phase of a contract should have a larger MR budget than the production phase, because the development phase is more uncertain or riskier. Likewise, price contracts are more risky to the contractor than cost-reimbursement contracts, and should have a larger MR budget.[2] Hypotheses describing these expectations are as follows:

H_1o: Median MR percent development ≤ Median MR percent production contracts

H_1a: Median MR percent development contracts > Median MR percent production contracts

H_2o: Median MR percent price contracts ≦ Median MR percent cost contracts

H_2a: Median MR percent price contracts > Median MR percent cost contracts

We also tested for differences in MR budgets across the military services (Army, Air Force, Navy) managing the contracts. An MR budget may differ across military services because of potential risk differences in weapon systems procured and used by each service and potential management differences across the contractors that build the systems. The hypothesis for this expectation is as follows:

H^3o: Median MR percent Army = Median MR percent Air Force = Median MR percent Navy contracts

H_3a: Median MR percent Army .˙. ≠ Median MR percent Air Force .˙. ≠ Median MR percent Navy contracts

A relative measure of an MR budget (MR percent) was used to control for differences in contract size, and is defined in Equation 1.

$$\text{MR percent} = \text{MR budget} \div \text{Total allocated budget} \quad (1)$$

For hypotheses 1 and 2, we used the nonparametric Mann-Whitney test (Conover, 1980, pp. 216–227). This test is appropriate when comparing the medians of two independent samples, and the data are at least ordinal (rank-order). When the Mann-Whitney test is significant, it indicates that there is a significant difference between the two sample medians. The more common one-sided *t*-test for differences in means is inappropriate because MR percent is not normally distributed.

For hypothesis 3, we used the nonparametric Kruskal-Wallace test, an extension of the Mann-Whitney test to two or more independent samples (Conover, 1980, pp. 229–237). When the Kruskal-Wallace test is significant, it indicates a significant difference between at least two of the sample

medians. The test does not indicate whether just two or more than two groups differ from each other. If the Kruskal-Wallace test is significant, then the Mann-Whitney test may be used to make the pairwise comparisons (Sheskin, 1997, pp. 404–405).

We computed the descriptive statistics on an MR budget and test the hypotheses in each quarter of the contract's life on percent complete, computed as shown in Equation 2.

$$\text{Percent complete} = \text{Budgeted cost of work performed} \div \text{Budget at completion} \quad (2)$$

The budgeted cost of work performed (BCWP), or earned value, is "the sum of the budgets for completed work and completed portions of open work packages, plus the applicable portion of budgets for level of effort and apportioned effort" (DoD, 1997, p. 59). The budget at completion (BAC) is the budget for all of the known work on the contract. As such, the BAC excludes the MR budget. At contract completion, the BCWP equals the BAC.

The Database

To develop the benchmarks and test for differences, we used data from the Defense Acquisition Executive Summary (DAES) database, maintained by the Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (OUSD [AT&L]). This database contains monthly cost and schedule performance data on more than 500 completed and ongoing defense contracts since the mid-1970s. The contractor summarizes the monthly cost and schedule status of the project on a cost performance report (CPR) and sends it to the government program office that is managing the project. Program offices summarize data from the CPRs on DAES reports and send them to OUSD(AT&L) for review and incorporation into the DAES database.

The reliability of the CPR is controlled by a requirement for the contractor to comply with earned value management systems (EVMS) criteria (formerly cost/schedule control systems criteria). The government assumes that if the contractor is criteria-compliant, then the CPR is reasonably reliable. Because the DAES database is derived from the CPR via the DAES report, we assume that the DAES database is also reasonably reliable.

The Sample

To develop the descriptive statistics and test the hypotheses, we included as many contracts as possible. Not all contracts in the DAES database were used because some lack the necessary data to compute MR percent or percent complete. To give all contracts an equal weight, only one MR percent from each contract was included in each quarter. Instead of limiting our sample to all contracts with data in each of the four quarters, we included any contract for which we can compute MR percent and percent complete in any quarter. This maximized the sample size in each quarter, but causes the total number of contracts to differ across quarters. The totals differ across quarters because some

"To develop the benchmarks and test for differences, we used data from the Defense Acquisition Executive Summary (DAES) database...."

contracts begin CPR reporting late, and others are terminated or stop reporting before they are 100 percent complete.

Results

Descriptive Statistics

Tables 1 through 3 show quarterly descriptive statistics on the amount of MR budgets on the sample of defense acquisition contracts from January 1975 to October 1998. MR budget percent (MR percent) and the TAB (in millions of dollars) are shown for the entire sample, and for various categories of the sample (acquisition phase, contract category, military service). In addition to the usual measures of central tendency and dispersion, the tables include selected percentiles for MR percent. Because the distribution of MR percent is not symmetrical, confidence intervals around the mean or median are not feasible.

"Our intent is to provide benchmarks useful for estimating an MR budget on new contracts or for comparing with an MR budget on ongoing contracts."

Our intent is to provide benchmarks useful for estimating an MR budget on new contracts or for comparing with an MR budget on ongoing contracts. In this regard, the values in the percentile columns in Tables 1 through 3 should be particularly useful. For example, as shown in Table 1, the amount of an MR budget on development contracts in the first quarter is 11 percent at the 95th percentile. This means that the MR budget on 95 percent of the development contracts in the sample is less than or equal to 11 percent. Assuming that the sample is representative of the population, establishing an MR budget in excess of 11 percent of the TAB for a new development contract would be very unusual. Similar comparisons can be made with ongoing contracts.

We could find only one prior study that reports DoD experience on MR percent. In 1980 the National Security Industrial Association surveyed more than 100 defense contractors with earned value experience. Seventy-four contractors responded. Results show that "initial reserve levels range from 0 to 16 percent of total contract value, with 68 percent of the responses falling into the 5 to 10 percent range" (NSIA, 1980, p. 11). The average MR percent reported is 6 percent (NSIA, 1980, p. IV-1). Using similar language, our results show that initial reserves range from 0 to 28 percent of total allocated budget, with about 90 percent of the contracts falling into the 5 to 10 percent range. The average MR percent is 4 percent.

The most frequent amount (mode) of an MR budget in all quarters and categories was zero. In the first quarter, 10 percent of all contracts in the sample had no budget for unforeseen but in-scope problems. In the remaining quarters, the result is the same, with 10 percent of all contracts having no MR budget.

With respect to nonzero amounts of MR budgets in the last quarter, one may be tempted to conclude that most defense contracts do not fully utilize the MR budget. This may not be true generally because most contracts stop CPR reporting before the 100 percent completion point. In our sample of 382 contracts in the fourth quarter, only one was 100 percent complete and it had no remaining MR

Table 1. Management Reserve Budget

		Management Reserve Budget (Percent)						Percentiles							Total Allocated Budget ($ Millions)				
Qtr.	Category	N	Mean	Median	Max	Min.	SD[a]	5th	10th	25th	50th	75th	90th	95th	Mean	Median	Max.	Min.	SD[a]
1	Develop	78	4.3	3.9	26.3	0.0	4.8	0.0	0.0	0.0	3.9	6.9	10.4	11.0	208	87	2523	12	326
	Produce	202	3.9	2.5	28.3	0.0	4.3	0.0	0.0	0.3	2.5	6.4	10.0	12.4	317	156	3020	5	413
	Cost	70	3.5	2.2	26.3	0.0	4.5	0.0	0.0	0.0	2.2	5.1	8.1	9.9	255	123	1478	12	295
	Price	210	4.2	3.0	28.3	0.0	4.5	0.0	0.0	0.2	3.0	6.9	10.4	12.4	297	142	3020	5	421
	Army	58	3.9	2.8	15.2	0.0	4.2	0.0	0.0	0.0	2.8	7.1	9.8	12.7	146	87	842	9	174
	Air Force	109	5.3	4.5	16.1	0.0	3.8	0.0	0.0	2.5	4.5	8.3	10.5	12.1	230	107	2823	10	388
	Navy	113	2.9	1.2	28.3	0.0	4.9	0.0	0.0	0.0	1.2	3.3	7.9	12.0	413	307	3020	5	443
	All	280	4.0	2.8	28.3	0.0	4.5	0.0	0.0	0.2	2.8	6.5	10.1	12.2	286	137	3020	5	394
2	Develop	98	4.8	4.2	24.2	0.0	4.6	0.0	0.0	0.6	4.2	7.4	10.9	12.7	209	86	3779	7	433
	Produce	234	4.1	3.0	18.7	0.0	3.9	0.0	0.0	0.9	3.0	6.1	9.6	12.3	345	167	3041	10	436
	Cost	82	3.8	3.1	24.2	0.0	4.2	0.0	0.0	0.5	3.1	5.5	7.8	11.3	228	96	1498	12	290
	Price	250	4.5	3.5	18.7	0.0	4.1	0.0	0.0	0.9	3.5	6.8	10.8	12.4	330	151	3779	7	476
	Army	72	3.8	3.0	12.3	0.0	3.5	0.0	0.0	0.5	3.0	5.9	9.2	11.4	155	93	851	7	174
	Air Force	125	5.8	5.1	16.4	0.0	3.9	0.0	1.3	2.5	5.1	7.9	11.6	13.4	274	112	3779	10	486
	Navy	135	3.2	1.5	24.2	0.0	4.3	0.0	0.0	0.3	1.5	4.6	7.6	12.1	413	218	3041	14	465
	All	332	4.3	3.4	24.2	0.0	4.1	0.0	0.0	0.9	3.4	6.6	10.4	12.4	305	143	3779	7	439
3	Develop	109	4.0	3.0	18.4	0.0	3.5	0.0	0.0	1.2	3.0	6.2	9.0	10.8	260	93	3899	7	560
	Produce	260	3.6	2.5	20.9	0.0	3.5	0.0	0.1	0.8	2.5	5.2	8.8	10.9	347	176	3080	14	430
	Cost	85	3.2	2.2	18.4	0.0	3.3	0.0	0.0	0.9	2.2	4.9	7.2	9.9	260	100	3899	11	479
	Price	284	3.8	2.7	20.9	0.0	3.6	0.0	0.1	1.0	2.7	5.9	9.0	11.0	339	158	3779	7	471
	Army	75	3.9	2.8	18.4	0.0	3.8	0.0	0.0	0.9	2.8	6.3	9.0	11.5	159	105	850	7	180
	Air Force	144	4.6	4.0	15.2	0.0	3.4	0.0	0.5	1.9	4.0	6.7	9.7	11.3	301	135	3779	14	478
	Navy	150	2.7	1.7	20.9	0.0	3.3	0.0	0.0	0.6	1.7	3.7	7.2	8.9	422	202	3899	16	542
	All	369	3.7	2.6	20.9	0.0	3.5	0.0	0.0	1.0	2.6	5.5	8.8	10.8	321.1	149	3899	7	473
4	Develop	106	3.1	2.0	12.7	0.0	2.9	0.0	0.0	1.0	2.0	5.0	7.3	9.0	300	109	3901	7	611
	Produce	276	3.1	1.9	20.2	0.0	3.5	0.0	0.0	0.4	1.9	4.5	8.1	10.1	346	163	6956	4	558
	Cost	93	2.3	1.6	12.7	0.0	2.6	0.0	0.0	0.3	1.6	3.2	5.2	8.8	275	105	3901	4	520
	Price	289	3.3	2.2	20.2	0.0	3.5	0.0	0.0	0.5	2.2	5.3	8.3	9.9	352	161	6956	7	588
	Army	77	2.5	1.8	11.8	0.0	2.7	0.0	0.0	0.2	1.8	3.8	6.5	8.7	160	111	850	4	175
	Air Force	144	4.0	3.4	14.5	0.0	3.4	0.0	0.0	1.0	3.4	6.1	9.1	11.2	358	159	6956	14	707
	Navy	161	2.6	1.4	20.2	0.0	3.3	0.0	0.0	0.4	1.4	3.5	7.1	9.7	394	161	3901	9	548
	All	382	3.1	2.0	20.2	0.0	3.3	0.0	0.0	0.5	2.0	4.5	7.8	9.7	333	150	6956	4	573

[a] Standard deviation.

Table 2. Management Reserve Budget (Contract Phase within Military Service)

Qtr.	Category	Management Reserve Budget (Percent)						Percentiles							Total Allocated Budget ($ Millions)				
		N	Mean	Median	Max	Min.	SD[a]	5th	10th	25th	50th	75th	90th	95th	Mean	Median	Max.	Min.	SD[a]
1	Army: Dev.	18	3.2	1.5	8.9	0.0	3.5	0.0	0.0	0.0	1.5	6.7	7.8	.	114	73	515	13	117
	Army: Prod.	40	4.2	3.2	15.2	0.0	4.5	0.0	0.0	0.0	3.2	7.2	12.0	12.7	160	93	842	9	194
	AF: Dev.	39	5.3	5.0	11.3	0.0	3.7	0.0	0.0	2.0	5.0	9.2	10.5	10.9	243	100	2523	12	408
	AF: Prod.	70	5.3	4.5	16.1	0.0	3.8	0.0	0.5	2.5	4.5	7.9	10.9	12.9	223	107	2823	10	379
	Navy: Dev.	21	3.4	0.1	26.3	0.0	6.9	0.0	0.0	0.0	0.1	3.7	17.1	25.7	222	67	878	21	267
	Navy: Prod.	92	2.7	1.2	28.3	0.0	4.4	0.0	0.0	0.0	1.2	3.3	8.0	11.7	456	322	3020	5	464
2	Army: Dev.	28	3.5	3.1	11.4	0.0	3.2	0.0	0.0	0.5	3.1	5.4	7.9	10.1	89	62	468	7	93
	Army: Prod.	44	4.0	3.0	12.3	0.0	3.7	0.0	0.0	0.7	3.0	6.1	10.3	11.8	196	127	851	12	200
	AF: Dev.	46	6.1	5.9	15.8	0.0	4.0	0.0	0.1	3.5	5.9	9.0	11.6	13.1	268	93	3779	15	573
	AF: Prod.	79	5.6	4.7	16.4	0.0	3.9	0.0	1.5	2.5	4.7	7.0	11.8	14.0	278	129	2845	10	432
	Navy: Dev.	24	4.0	2.0	24.2	0.0	6.2	0.0	0.0	0.0	2.0	4.9	15.3	23.2	234	96	1534	22	339
	Navy: Prod.	111	3.0	1.4	18.7	0.0	3.7	0.0	0.0	0.4	1.4	4.2	7.5	10.4	451	302	3041	14	481
3	Army: Dev.	30	4.0	2.4	18.4	0.0	4.3	0.0	0.0	1.1	2.4	5.8	9.2	15.4	91	45	629	7	121
	Army: Prod.	45	3.8	2.9	11.8	0.0	3.5	0.0	0.0	0.7	2.9	6.7	8.9	11.1	204	150	850	17	200
	AF: Dev.	50	4.8	4.6	11.4	0.0	3.2	0.0	0.3	2.2	4.6	7.0	9.3	10.8	285	99	3779	15	564
	AF: Prod.	94	4.5	3.8	15.2	0.0	3.5	0.0	0.5	1.8	3.8	6.4	9.9	11.9	309	143	2793	14	427
	Navy: Dev.	29	2.5	1.7	11.2	0.0	2.8	0.0	0.0	0.5	1.7	3.2	6.3	9.9	285	99	3779	15	564
	Navy: Prod.	121	2.7	1.7	20.9	0.0	3.4	0.0	0.0	0.6	1.7	3.7	7.4	9.1	428	220	3080	21	477
4	Army: Dev.	28	2.2	1.8	7.3	0.0	2.0	0.0	0.0	0.4	1.8	3.5	5.5	6.9	114	87	628	7	129
	Army: Prod.	49	2.6	1.9	11.8	0.0	3.0	0.0	0.0	0.1	1.9	3.9	7.5	9.3	187	120	850	4	193
	AF: Dev.	45	4.2	4.0	12.7	0.0	3.3	0.0	0.0	1.4	4.0	6.7	8.8	10.2	318	146	3775	15	594
	AF: Prod.	99	3.8	3.2	14.5	0.0	3.5	0.0	0.0	0.6	3.2	5.7	9.2	11.4	376	161	6956	14	755
	Navy: Dev.	33	2.3	1.5	11.1	0.0	2.6	0.0	0.0	0.7	1.5	3.2	6.3	9.3	434	112	3901	16	822
	Navy: Pro.	128	2.6	1.3	20.2	0.0	3.5	0.0	0.0	0.4	1.3	3.8	7.2	9.9	383	194	3122	9	456

[a] Standard deviation.

Table 3. Management Reserve Budget (Contract Type within Military Service)

Qtr.	Category	Management Reserve Budget (Percent) N	Mean	Median	Max	Min.	SD[a]	Percentiles 5th	10th	25th	50th	75th	90th	95th	Total Allocated Budget ($ Millions) Mean	Median	Max.	Min.	SD[a]
1	Army: Cost	16	2.9	0.2	8.9	0.0	3.5	0.0	0.0	0.0	0.2	6.8	8.0	.	115	65	515	13	123
	Army: Price	42	4.3	3.2	15.2	0.0	4.4	0.0	0.0	0.0	3.2	7.1	11.6	12.7	157	93	842	9	190
	AF: Cost	20	4.8	4.4	10.5	0.0	2.7	0.2	1.6	3.2	4.4	6.2	9.5	10.5	186	85	647	12	177
	AF: Price	89	5.4	5.3	16.1	0.0	4.0	0.0	0.0	2.0	5.3	8.4	10.9	12.6	240	108	2823	10	421
	Navy: Cost	34	3.0	1.5	26.3	0.0	5.6	0.0	0.0	0.0	1.5	3.4	7.0	21.5	362	281	1478	20	365
	Navy: Price	79	2.8	1.0	28.3	0.0	4.6	0.0	0.0	0.0	1.0	3.3	8.2	11.9	435	309	3020	5	473
2	Army: Cost	27	3.2	2.2	11.4	0.0	3.2	0.0	0.0	0.0	2.2	5.4	8.0	10.2	86	60	468	12	93
	Army: Price	45	4.1	3.0	12.3	0.0	3.6	0.0	0.0	0.9	3.0	6.1	10.2	11.8	196	128	851	7	198
	AF: Cost	19	5.2	4.6	12.6	0.0	2.9	0.0	1.8	3.3	4.6	7.2	8.4	.	183	79	648	21	190
	AF: Price	106	5.9	5.1	16.4	0.0	4.1	0.0	1.2	2.5	5.1	9.0	11.8	13.8	291	121	3779	10	521
	Navy: Cost	36	3.4	1.8	24.2	0.0	5.2	0.0	0.0	0.2	1.8	4.2	8.4	20.6	359	216	1498	22	368
	Navy: Price	99	3.1	1.3	18.7	0.0	3.9	0.0	0.0	0.4	1.3	4.7	7.7	11.9	432	218	3041	14	496
3	Army: Cost	28	4.0	2.4	18.4	0.0	4.3	0.0	0.0	1.1	2.4	5.4	9.3	16.0	91	45	629	11	123
	Army: Price	47	3.9	2.9	11.8	0.0	3.5	0.0	0.0	0.7	2.9	7.0	9.1	11.0	200	150	850	7	197
	AF: Cost	21	4.6	3.9	10.3	0.0	2.6	0.3	1.1	3.1	3.9	6.9	8.5	10.1	194	79	647	21	201
	AF: Price	123	4.6	4.1	15.2	0.0	3.6	0.0	0.4	1.7	4.1	6.7	10.0	11.4	319	143	3779	14	508
	Navy: Cost	36	1.8	1.4	11.2	0.0	2.2	0.0	0.0	0.2	1.4	2.3	5.1	6.6	430	203	3899	16	678
	Navy: Price	114	3.0	1.9	20.9	0.0	3.5	0.0	0.0	0.6	1.9	4.0	7.5	9.6	419	201	3080	21	495
4	Army: Cost	28	1.9	1.8	6.4	0.0	1.8	0.0	0.0	0.0	1.8	3.1	5.0	5.9	103	54	628	4	131
	Army: Price	49	2.8	1.9	11.8	0.0	3.0	0.0	0.0	0.4	1.9	4.6	7.5	9.3	193	135	850	7	190
	AF: Cost	21	3.3	2.5	12.7	0.0	3.3	0.0	0.0	0.9	2.5	4.6	8.9	12.3	193	93	658	23	199
	AF: Price	123	4.1	3.5	14.5	0.0	3.5	0.0	0.0	1.0	3.5	6.2	9.1	11.2	386	164	6956	14	758
	Navy: Cost	44	2.1	1.5	11.1	0.0	2.5	0.0	0.0	0.4	1.5	2.6	4.9	9.7	424	139	3901	16	709
	Navy: Price	117	2.7	1.3	20.2	0.0	3.6	0.0	0.0	0.4	1.3	3.9	7.3	9.8	382	183	3122	9	477

[a] Standard deviation.

Table 4. Comparions of Median Management Reserve Budget Percent

Qtr.	Comparison	Median MR% Difference	Z	Significance	
1	Production–Development	–1.4	–0.166	0.434	1-tailed
	Cost–Price	–0.8	–1.434	0.076	1-tailed
	Army–Air Force	–1.7	–2.509	0.012	2-tailed
	Army–Navy	1.6	–1.607	0.108	2-tailed
	Air Force–Navy	3.4	–7.036	0.000	2-tailed
2	Production–Development	–1.2	–1.168	0.122	1-tailed
	Cost–Price	–0.4	–1.600	0.055	1-tailed
	Army–Air Force	–2.1	–3.596	0.000	2-tailed
	Army–Navy	1.5	–1.753	0.080	2-tailed
	Air Force–Navy	3.6	-6.468	0.000	2-tailed
3	Production–Development	–0.6	–1.145	0.126	1-tailed
	Cost–Price	–0.5	–1.392	0.082	1-tailed
	Army–Air Force	–1.2	–1.947	0.052	2-tailed
	Army–Navy	1.2	–2.303	0.021	2-tailed
	Air Force–Navy	2.4	–5.712	0.000	2-tailed
4	Production – Development	–0.1	–0.965	0.167	1-tailed
	Cost – Price	–0.6	–2.106	0.018	1-tailed
	Army – Air Force	–1.6	–3.175	0.001	2-tailed
	Army – Navy	0.4	–0.369	0.712	2-tailed
	Air Force – Navy	2.0	–4.036	0.000	2-tailed

budget. Only 14 contracts were greater than 95 percent complete. Of these, nine reported no remaining MR budget.

COMPARISONS

The results of the hypothesis tests were mixed. Figures 1 through 3 show the median quarterly MR percentages across acquisition phase, contract category, and military services. Table 4 shows quarterly differences in the median MR percentages, and the results of testing the three hypotheses.

Figure 1 compares the quarterly median MR percent by acquisition phase. Although the median MR percent on development contracts is greater than the median MR percent on production contracts for each quarter, the differences are not significant. Null hypothesis 1 could not be rejected. The MR budget is not sensitive to acquisition phase.

Figure 2 compares the quarterly median MR percent by contract category. The median MR percent on fixed-price contracts is greater than the median MR percent on cost-reimbursable contracts for each quarter. The differences are significant in

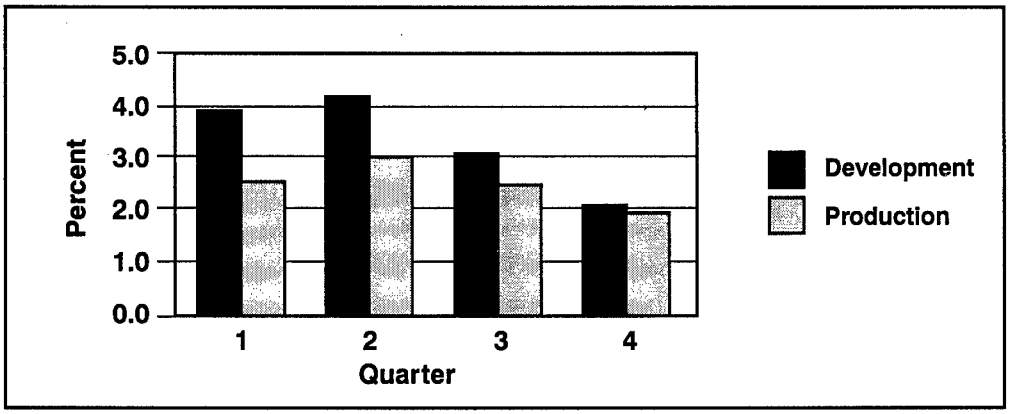

Figure 1. Median Management Reserve Budget by Acquisition Phase

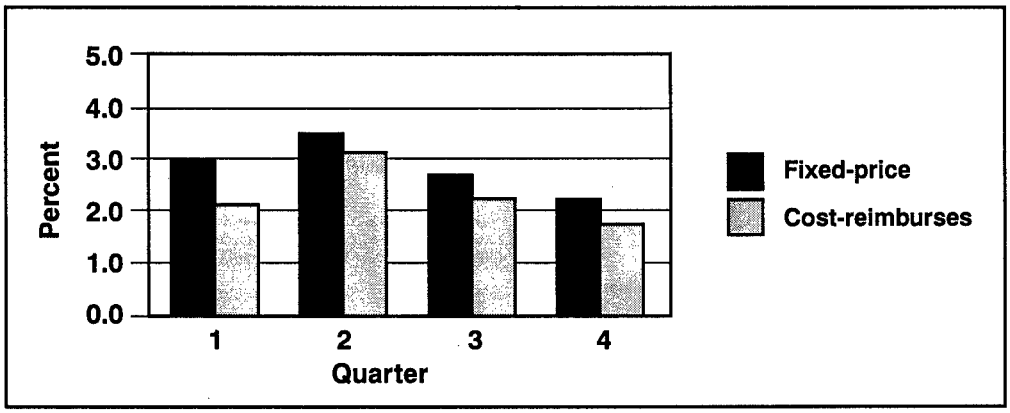

Figure 2. Median Management Reserve Budget by Contract Category

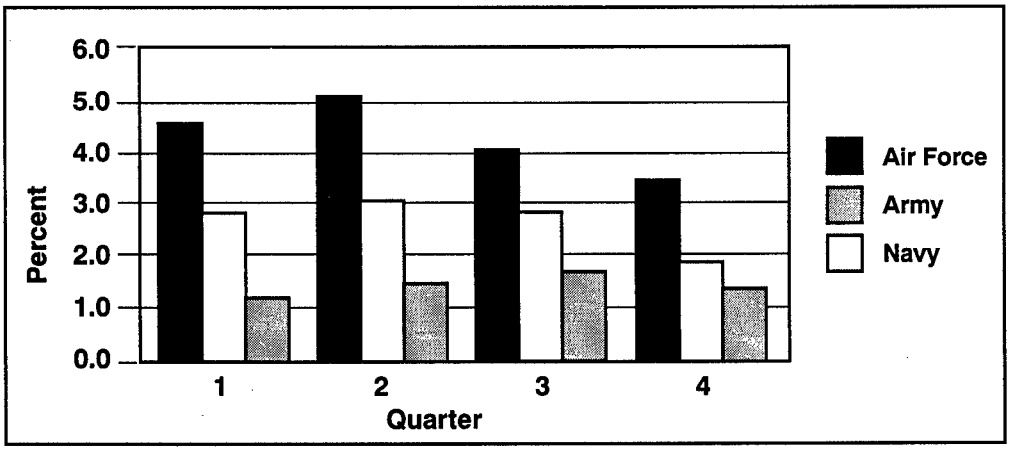

Figure 3. Median Management Reserve Budget by Military Service

all quarters (one-tailed $p < .1$). Null hypothesis 2 is rejected. The MR budget is sensitive to the category of contract.

Figure 3 compares the quarterly median MR percent by military service. Differences in the median MR percent across contracts managed by the military services are highly significant (Kruskal-Wallace two-tailed $p < .000$) in each quarter. Most of the pairwise comparisons (Army with Air Force, Army with Navy, and Air Force with Navy) are also significant (Mann-Whitney two-tailed $p < .1$) in each quarter. Null hypothesis 3 is rejected. The MR budget is sensitive to the military service managing the contract.

Conclusion

An MR budget is a management construct with multiple purposes. As a planning tool, it represents the contractor's estimated cost of unforeseen but in-scope work. Determining an accurate amount of an MR budget is an important part of risk management on the contract. As a control tool, an MR budget is used to adjust the performance measurement baseline. Including budget in the baseline for newly identified but in-scope work makes variance analysis more meaningful. As a motivation tool, an MR budget creates incentives for control account managers and others to operate more efficiently.

Given these multiple purposes, determining an appropriate amount for the MR budget is necessarily an iterative process that requires input from managers at various levels in the contractor organization. The process depends on many factors, including risk, management philosophy, time constraints, experience, and the bargaining skills of the managers. Risk management models that determine the MR budget may make the process more systematic, but they should not replace management judgment.

Experience with MR budgets on completed and ongoing contracts from 1975 to 1998 may be useful as benchmarks for determining initial reserve amounts, and for evaluating usage during contract performance. Quarterly descriptive statistics on DoD experience with MR budgets are provided in several tables.

In addition to the descriptive statistics, the amount of an MR budget is sensitive to contract category (cost-reimbursable versus fixed-price), and the managing service. With regard to contract category, the median MR percent on fixed-price contracts is significantly greater than the median MR percent on cost-reimbursable contracts. This is consistent with the expectation that contracts with more risk to the contractor have a larger MR budget. We do not know why MR budgets differ across the three services. Possible explanatory factors include differences in the weapon systems purchased by each service, and the contractors that build the systems.

ENDNOTES

1. In this article, we use the terms "risk" and "uncertainty" as synonyms.
2. The contractor establishes an MR budget, not the government. In theory, then, an MR budget should be more reflective of risk to the contractor than risk to the government.

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References

Antolini, R. C., Christensen, D. C., & Bowman, T. (1991, September). *Interpretive guide to the evaluation/ demonstration review checklist for C/ SCSC.* Wright-Patterson AFB, OH: Air Force Institute of Technology.

Artto, K. A. (1994, Fall). Life-cycle costs and methodologies. *Journal of Cost Management,* 28–32.

Barrett, M. E., & Fraser , L. B. III (1977, July-August). Conflicting roles in budgeting for operations. *Harvard Business Review 55,* 137–146.

Bart, C. K. (1988). Budgeting gamesmanship. *Academy of Management Executive,* 285–294.

Blocher, E. J., Chen, K. H., & Lin, T. W. (1999). *Cost management, a strategic emphasis.* Black Lick, OH: Irwin, McGraw-Hill.

Bowman, T. L. (1993, March). Estimating, planning, and budgeting for contingency in the DOE environment. *In Control,* 3–13.

Coleman, R. L., Gupta, S. S., Blackburn, F. K., & St. Louis, N. L. (1998, June). Implementation of an initial cost as an independent variable (CAIV) and total ownership cost (TOC) process in the Navy's Acquisition Center of Excellence (ACE). *Journal of Parametrics* (special ed.), 147–198.

Conover, W. J. (1980). *Practical nonparametric statistics* (2nd ed). New York: John Wiley & Sons.

Department of Defense (1997, October 3). *Earned value management implementation guide.* Washington, DC: Author.

Fleming, Q. W. (1992). *Cost/schedule control systems criteria* (rev. ed.). Chicago, IL: Probus Publishing.

Fleming, Q. W., & Koppelman, J. M. (1996). *Earned value project management.* Upper Darby, PA: Project Management Institute.

Garrison, R. H., & Noreen, E. W. (2000). *Managerial accounting* (9th ed.). Boston, MA: McGraw-Hill.

Garvey, P. R. (1995, Spring). A family of joint probability models for cost and schedule uncertainties. *Journal of Cost Analysis,* 155–200.

Gould, K. T. (1995). *An analysis of the purpose and development of management reserve.* Masters thesis. Wright-Patterson AFB, OH: Air Force Institute of Technology.

Horngren, C. T., Foster, G., & Datar S. M. (2000). *Cost accounting, a managerial emphasis* (10th ed.). Upper Saddle River, NJ: Prentice Hall.

Goldberg, M. S., & Weber, C. A. (1998, August). *Evaluation of the risk analysis and cost management (RACM) model* (IDA Paper P-3388). Alexandria, VA: Institute for Defense Analysis.

Merchant, K. A. (1985). Budgeting and the propensity to create budgetary slack. *Accounting, Organization and Society 10,* 201–210.

Merchant, K. A. (1998). *Modern management control systems.* Upper Saddle River, NJ: Prentice Hall.

Merchant, K. A. , & Shields, M. D. (1993, June). When and why to measure costs less accurately to improve decision making. *Accounting Horizons 7,* 76–81.

Merchant, K. A. , & Manzoni, J-F. (1989, July). The achievability of budget targets in profit centers: A field study. *The Accounting Review 64,* 539–558.

National Security Industrial Association. (1980, September 16). *NSIA cost/schedule systems compendium.* Washington, DC: Author.

Sheskin, D. J. (1997). *Handbook of parametric and non-parametric statistical procedures.* New York: CRC Press.

Slemaker, C. M (1985). *The principles and practice of cost schedule control systems.* Princeton, NJ: Petrocelli Books.

Stewart, R. D., & Wyskida, R. M. (1987). *Cost estimator's reference manual.* New York: John Wiley & Sons.

Tanaka, T. (1993, Spring). Target costing at Toyota. *Journal of Cost Management,* 4–11.

Umpathy, S. (1987). *Current budgeting practices in U.S. industry: The state of the art.* Quorum Publishers.

TUTORIAL

AIRCRAFT COST GROWTH AND DEVELOPMENT PROGRAM LENGTH: *SOME AUGUSTINIAN PROPOSITIONS REVISITED*

Henry L. Eskew, Ph.D.

This paper examines two notions that were popularized by Norman Augustine. The first is that growth in the cost of successive generations of tactical aircraft is more an inherent (time-driven) characteristic of such programs than a reflection of changes in their technical parameters. The second is that the design and build phase of aircraft development programs has remained virtually unchanged for 40 years, implying that no systematic relationship exists between the characteristics of a program and the length of its development cycle. Models resulting from this examination, which suggest certain modifications to Augustine's original propositions, are tested against recent data from the F/A–18E/F program.

More than a decade ago, Norman Augustine (1986, p. 143) provided a humorous characterization of growth in the costs of military aircraft:

> In the year 2054, the entire defense budget will purchase just one aircraft. This aircraft will have to be shared by the Air Force and Navy 3-1/2 days each per week except for leap year, when it will be made available to the Marines for the extra day.

Augustine actually produced a scatter plot and some trend lines to support this prophecy. Elsewhere in the same publication he wrote (1986, p. 140):

> ...the cost of an individual airplane has unwaveringly grown by a factor of four every 10 years. This rate of growth seems to be an inherent characteristic of such systems, with the unit cost being most closely correlated with the passage of time rather than with changes in maneuverability, speed,

weight, or other technical parameters.

Even the most casual observer of the defense marketplace would agree that long-term growth in the costs of tactical aircraft has been substantial. When Augustine says that unit cost has grown by a factor of four every 10 years, which equates to an annual growth rate of 15 percent, he makes no adjustment for the normal increase in manufacturing prices over time—inflation. Other factors having a bearing on aircraft unit costs (besides changes in technical characteristics) are first, the total procurement quantity of a given type and model—the so-called learning-curve effect—and second, the number of units produced in a given year—the production-rate effect.

This article seeks first to disentangle these factors—inflation, technical characteristics, learning, and production rate—from the growth in aircraft costs experienced over a 30-year period (1950–1980). The result constitutes an estimate of the real rate of cost growth, meaning the rate that is associated strictly with the passage of time. That result is then tested against data from a current program, the Department of the Navy's F/A–18E/F, in an effort to see if the same rate of cost growth continues, or—as one would hope—if it has abated to some degree.

Another of Augustine's propositions (1986, p. 356), and one of considerable interest in defense acquisition circles, is the following:

> The duration of the design and build phase of aircraft development programs has remained virtually unchanged for 40 years. This period is approximately the same for government projects, commercial projects, and, for that matter, projects undertaken in the Soviet Union.

Based on a scatter plot showing no trend between months-to-first-flight and year-of-first-flight for a combined set of military and commercial aircraft, this statement strongly implies that no systematic relationship exists between the characteristics of an aircraft program and the length of its development cycle. Historical data examined later in this article suggest that the length of a tactical aircraft development program has been systematically related to a standardized measure of the aircraft's eventual procurement cost. We consider the cost measure to be a proxy for program complexity or sophistication. As with the trend in cost growth, we tested that relationship against recent data from the F/A–18E/F program.

Tactical Aircraft Costs

A consistent source of procurement cost and technical characteristics data (McNichols, 1983) was available for 17 fighter and attack aircraft programs. The oldest of those was the F–89. The year in which its first operationally configured production unit was delivered—the measure of time employed throughout the paper—was 1950. The most recent aircraft is the F–18A; its year of first delivery was 1980. The other programs were the A–4, A–6, A–7, A–10; F–4, F–14, F–15, F–16, F–100, F–101, F–102, F–104, F–105, F–106, and F–111.

Measures of unit flyaway cost—the cleanest quantification of procurement cost—were constructed as follows, with flyaway defined to include airframe, engine, electronic, and armament costs, but not spare parts or other support items. First, to eliminate the learning-curve effect, we focused on the cost of the 100th production unit. Because military aircraft are procured in lots rather than by individual units, the cost of unit 100 can only be approximated. Dividing total annual flyaway cost in the year that included the 100th unit by that year's procurement quantity gives an approximate unit-100 cost in undeflated dollars. Then, to remove the effects of inflation, we applied a procurement-cost deflator (Office of the Secretary of Defense, 1991) to convert the cost measures to constant fiscal year 1990 dollars. Figure 1 is a plot of approximate unit-100 flyaway cost in millions of 1990 dollars against year of first delivery.

Estimating the Rate of Cost Growth

Before proceeding further, a quick analysis of the data in Figure 1 is instructive. A simple regression of cost—actually the logarithm of cost—on the time variable provides an estimate of the rate of annual cost growth before the effects of technical characteristics and production rate are accounted for. The regression resulted in an estimated growth rate of 5 percent per year. Although that estimate easily passed tests of statistical significance, the time variable—year of first delivery—explained less than 40 percent

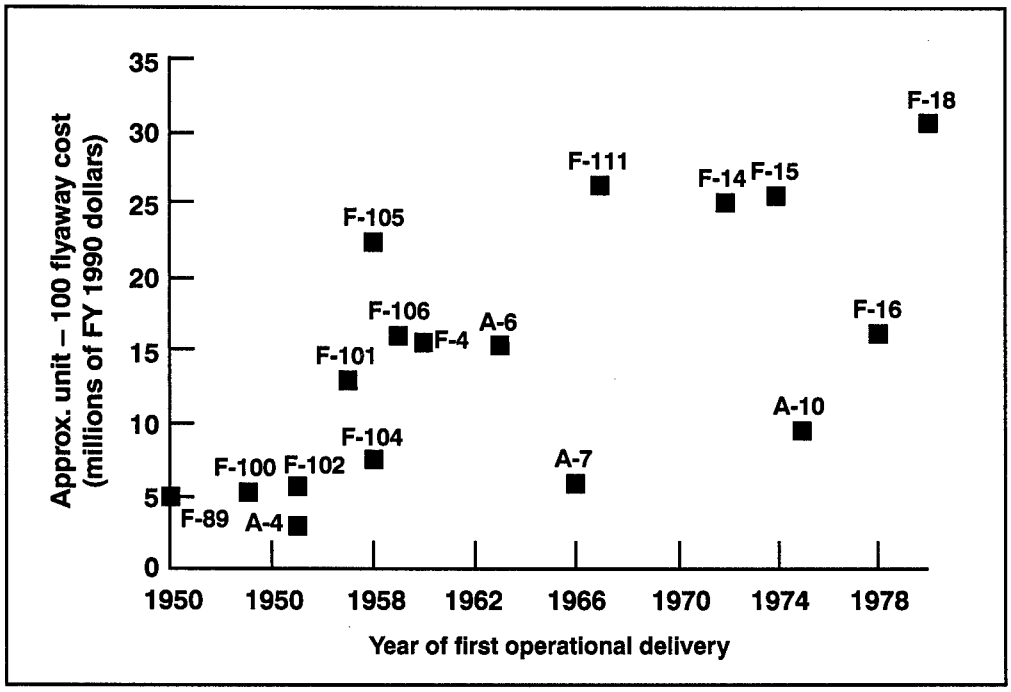


Figure 1. Flyaway Cost Versus Year of First Delivery

of the variation in cost among the 17 aircraft.[1] This relatively low level of explanatory power is consistent with the notion that other factors are systematically influencing cost.

The next step was to bring technical characteristics and production rate into play. That was done by adding three additional predictor variables to the regression model:

- aircraft empty weight (thousands of pounds);
- maximum speed at altitude (knots); and
- production rate in year of unit 100.

Augustine had mentioned maneuverability as another technical characteristic, but even if the requisite data were available —and they were not—maneuverability is a difficult characteristic to quantify.

Results of the regression of cost on weight, speed, production rate, and time were quite satisfactory.[2] All measures of statistical significance were unambiguously high, and the four predictor variables explained more than 90 percent of the variation in cost. Other results of note were:

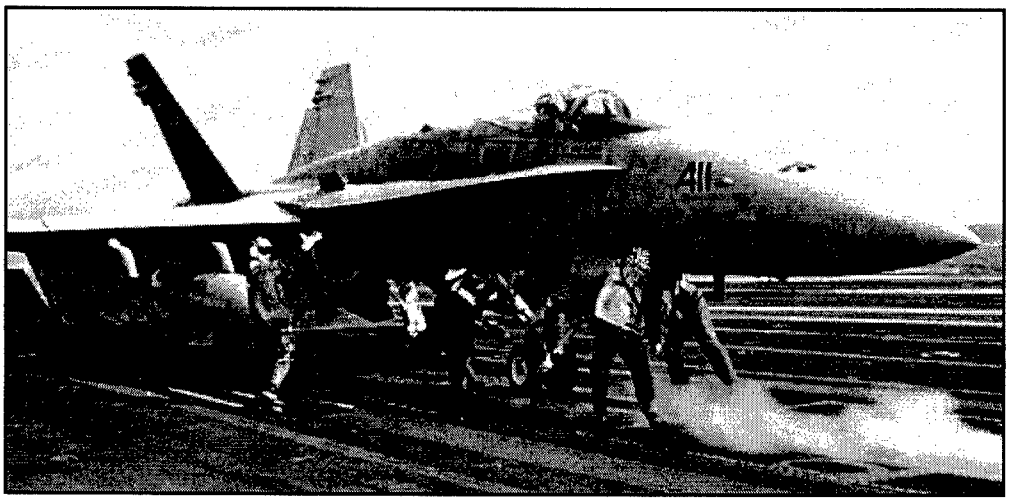
- The estimated annual rate of real cost growth declined to slightly more than 3 percent.
- A 10-percent increase in empty weight is estimated to lead to an increase in cost of roughly 7 percent.
- A 10-percent increase in maximum speed is estimated to lead to a cost increase of about 6 percent.
- A doubling of annual production rate is estimated to lead to a reduction in unit cost of roughly 25 percent.

The fact that the weight, speed, and production rate variables were found to play important roles in the model suggests that the accompanying growth-rate estimate—3.3 percent to be exact—is more reliable than the estimate of 5 percent produced by the first regression. There the time variable was almost certain to be picking up some of the effects of the other variables excluded from that model.[3]

The F/A–18E/F As a Test Case

The results just described are drawn from 17 different aircraft programs over a 30-year period. That is a substantial experience base. On the other hand, two decades have passed since the last entry to that database occurred. Is it reasonable to assume that the relationship that prevailed then remains in effect today—especially in light of the sweeping changes in technology that have taken place since 1980? Fortunately some new data—from the F/A–18E/F program—provide at least partial insight into that question.

The F/A–18E/F is a high-performance tactical aircraft designed to meet Navy and Marine Corps fighter escort, interdiction, fleet air defense, and close air support mission requirements, and to counter the advanced threat of the first part of the next century. The program was initiated in July 1987 in response to a directive from the Secretary of Defense to the Secretary of the Navy. The Defense Acquisition Board approved entry into Engineering and Manufacturing Development in May



The databases most recent tactical aircraft – the F-18A

1992. Low-rate initial production began in March 1997, with delivery of the first operational unit occurring in December 1998.

The program's most recent *Selected Acquisition Report* (SAR) (Department of the Navy, 1998) provides weight, speed, production rate, cost, and delivery-date information.[4] The approximate unit-100 flyaway cost reported there is $49 million in constant fiscal year 1990 dollars.[5] When the regression results described in the preceding section are combined with the relevant technical and programmatic information, the comparable cost prediction (fiscal year 1990 dollars) is $65 million.[6]

From a practical standpoint, the big difference in those two numbers—more than 30 percent—might suggest that the long-term rate of cost growth has abated to some degree. Statistically, however, things are less clear. One way of looking at the statistical picture is to note that the lower bound of a 90-percent confidence interval placed around the $65 million prediction is less than $44 million. This means that the SAR cost is well within the uncertainty limits of the original regression.[7] Another statistical look comes from noting that changing the annual growth rate from 3.3 percent to 3.0 percent would result in a prediction of exactly $49 million. Such a change is easily within the noise of the original estimate. This observation also serves as a reminder of a lesson well known by all: Small changes in rates of compound growth can make huge differences over long periods of time.

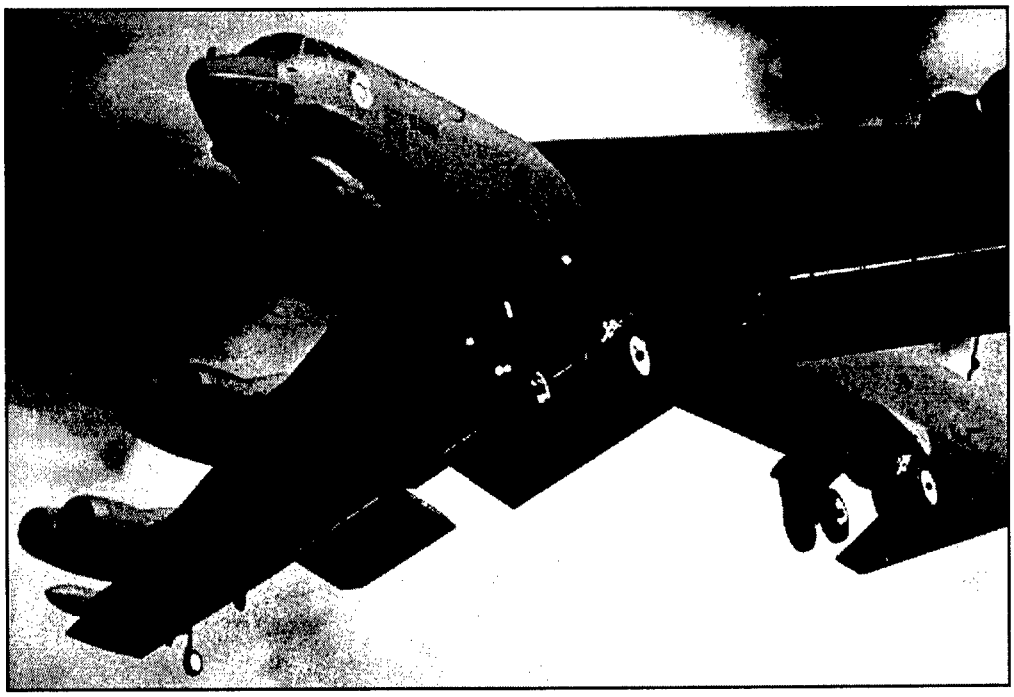
Tactical Aircraft Development Program Length

As noted earlier, the length of a new aircraft's development program—defined here as the time between program initiation and delivery of the first operational unit—has been a variable of considerable interest in Defense acquisition circles for a long while. Drawing from a database of acquisition milestones developed at RAND

(Rothman, 1987), this section examines an empirical relationship between that variable and the eventual procurement cost of the aircraft in question. In fact, the same cost measure employed in the preceding sections—approximate unit-100 flyaway cost in constant 1990 dollars—proves to be a reliable predictor of development-program length. Predictive accuracy is improved considerably when the presence of inherited technology is taken into account.

The RAND database, which was also the source of the year-of-first-delivery data used in the cost analysis, includes fixed-wing aircraft, helicopters, and tactical missile systems. The aircraft programs examined here differed a bit from those on which the cost analysis was based. Here all fixed-wing aircraft in the database were included, provided complete cost and development-program data were available. The absence of complete data eliminated the A–4 and F–106, but the B–47, B–52, and S–3 were added, having been previously excluded because the cost analysis was restricted to fighter and attack aircraft. The result was a sample that consisted of 18 programs.

Based on program descriptions in the milestones database, two of the aircraft were singled out as having benefited from inherited technology, thereby causing each to experience an abbreviated development cycle. North American's F–100 Super Sabre evolved from its F–86 Sabre. In addition, the firm had invested one year of its own in development before working with the Air Force. Grumman's F–14 inherited engines and avionics from the



The B–52 Bomber

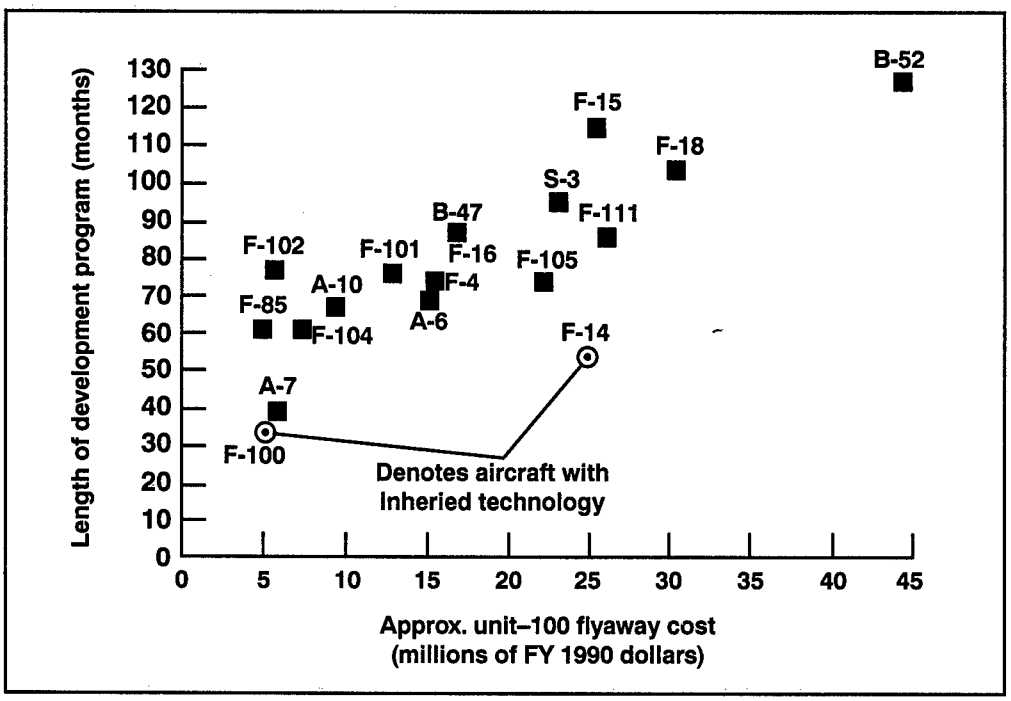


Figure 2. Development-Program Length Versus Flyaway Cost

canceled F–111B program, enabling Tomcat development and production to proceed rapidly. Those two programs are highlighted in Figure 2, which is a plot of development-program length (in months) versus flyaway cost.

The data in Figure 2 were analyzed statistically by a strictly linear regression model with program length as the dependent variable. The predictors were flyaway cost and a dummy variable defined to have a value of one for the F–100 and F–14 and zero otherwise. Results are shown in Table 1.

The first equation is a simple regression of program length on cost. In Equation 2, the dummy variable representing inherited technology is introduced. Its presence increases the model's explanatory power ($\bar{R}^2$) from 0.601 to 0.799, and decreases the standard error of estimate (SEE) from 15.2 to 10.8 months. The *t*-ratios shown in parentheses indicate that each of the estimated regression coefficients is significant at better than the 0.005 level. Values of the coefficients in the preferred (second) equation may be interpreted as follows:

- Each increase of $1 million in the standardized measure of aircraft cost leads to a 1.7-month increase in the length of the development program.

- Inheritance of technology from predecessor programs can shorten the development cycle significantly. For the two aircraft considered here, the development cycles appear to have been reduced by about 3 years (33 months).[8]

Table 1. Regressions with Development-Program Length as the Dependent Variable

Equation	Constant	Cost	Dummy	$\bar{R}^2$	S.E.E.
1	45.707 (6.535)	1.798 (5.195)	—	.601	15.2
2	50.709 (9.239)	1.714 (6.943)	–33.147 (–4.097)	.799	10.8

A similar question arises here as arose in the cost analysis: Does this historical relationship remain in existence? Again the F/A–18E/F provides a test case. That program officially began in July 1987, with December 1998 being the date for first delivery. That period spans 137 months. Substituting the SAR flyaway cost ($49 million) into Equation 2 leads to a predicted development-program length of 135 months. The closeness of these two numbers speaks for itself. In generating this prediction, the technology dummy was not activated, meaning the variable was set to zero. That treatment seems appropriate in light of the fact that the F/A–18E/F has an altogether different airframe and propulsion system than the predecessor F–18 aircraft, and it is also designed to accommodate avionics growth.

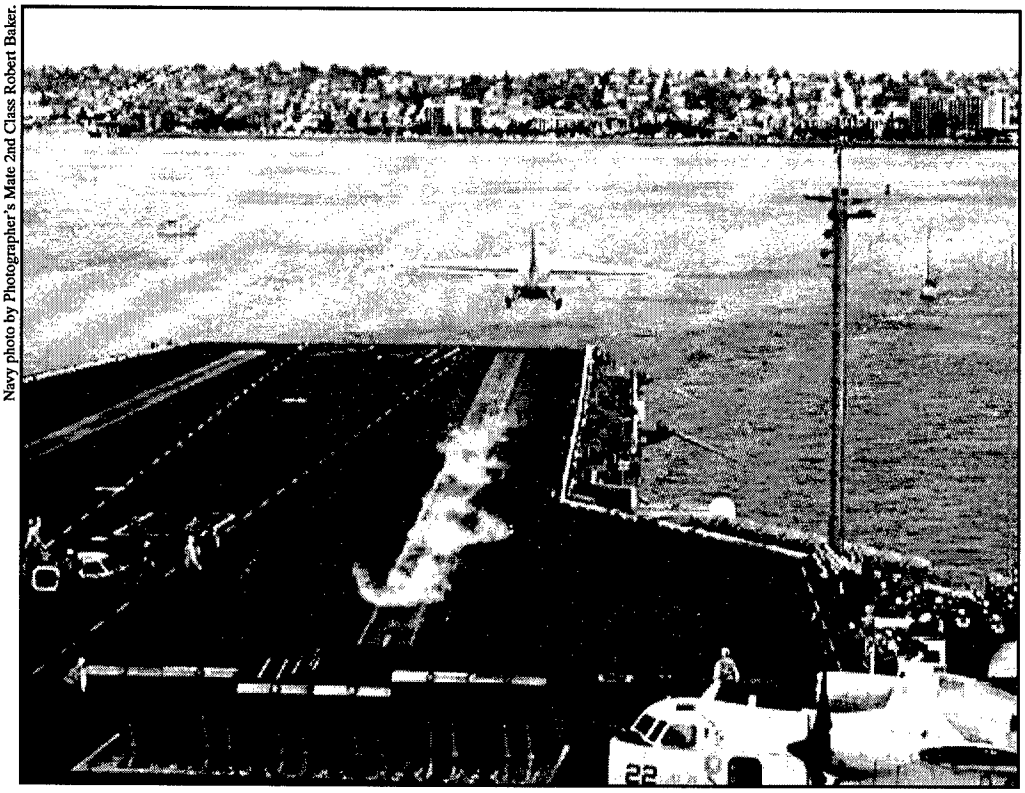
Summary and Concluding Remarks

This article has focused first on the rate of long-term growth in tactical aircraft costs that cannot be attributed to normal inflation, learning-curve and production-rate effects, and changes in aircraft technical characteristics. That growth rate was estimated to be slightly more than 3 percent per year, a result quite a bit lower than what one obtains by examining a simple cost versus time relationship. The suggestion has been made that this otherwise unexplained cost growth may represent investment in increased aircraft service lives.[8] That is certainly an interesting and promising hypothesis, but one that was not tested here.

Compared with the highly detailed aircraft cost models that are presently available, the single regression equation used here constitutes at best a rough-and-ready device for predicting costs. And, of course, these results incorporate no experience with low-observable technology. Nevertheless, when combined with current information from the F/A–18E/F program, they build something of a bridge between past and present, suggesting the possibility of a decline in cost growth, albeit unconfirmed statistically.

The rough-and-ready characterization given to the cost equation is equally applicable to the empirical relationship between procurement cost and development-program length. Still, tools such as these can serve two useful purposes. They may on occasion provide independent corroboration of estimates based on detailed program information, and they may also emit

Navy photo by Photographer's Mate 2nd Class Robert Baker.



An S-3 Viking, attached to Air Anti-submarine Squadron Three Three (VS-33), takes off from the flight deck of USS John C. Stennis (CVN 74) in the San Diego Harbor.

early warning signals concerning optimistic projections of program outcomes. Recent experience suggests that the latter possibilities are hardly remote.

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References

Augustine, N. R. (1986). *Augustine's laws.* New York: Viking Penguin.

Department of the Navy. (1998, December 31). *Selected acquisition report: F/A–18E/F.* Washington, DC: Author.

Durbin, J. (1954) Errors in variables. Review of the International Statistics Institute, 22, 23–32.

Greene, W. H. (1990). *Econometric analysis.* New York: Macmillan.

McNichols, G. R. et al.(1983). *U.S. military aircraft cost handbook.* Falls Church, VA: Management Consulting & Research, Inc.

Office of the Secretary of Defense. (1991, March). *National defense budget estimates for FY 1992.* Washington, DC:Author.

Rothman, M. B. (1987, October). *Aerospace weapon system acquisition milestones: a data base.* Santa Monica, CA: The RAND Corporation.

ENDNOTES

1. References here and later in the article to the percent of variation in the dependent variable explained by the regression reflect adjustments for degrees of freedom in the analysis.

2. The model is linear in time and in the logarithms of all other variables.

3. The technical term for this is specification bias.

4. The speed value given in the *Selected Acquisition Report* is for an altitude of 10,000 feet with intermediate rated thrust. That is a different measure than maximum speed at altitude, which is the measure used in the database from which the regression equation was developed. Therefore, for purposes of this test, we used the database's speed for the F/A–18A/B, 990 knots. A comparison of aircraft weight and engine thrust data between the A/B and E/F models suggests that this is a reasonable number.

5. Two comments are in order concerning this cost. First, strictly speaking it is an estimate in that unit 100 has not yet been constructed. However, the cost is taken from budget submission data and is therefore a "budget quality" estimate. Second, because unit 100 falls in the lot that includes units 99 through 140, the best approximation of the cost of that unit can be obtained by averaging the lots that include units 63 through 98 and 99 through 140. That result is the $49 million reported above. For comparison, the cost drawn from the lot containing units 99 through 140 is $48 million.

6. The prediction equation is ln(cost) = −4.281 + 0.7125ln (weight) + 0.6187ln (speed) − 0.3911ln (prod. rate) + 0.0326 (time). Values of the predictor variables are weight = 30.196, speed = 990, production rate = 39 (a two-lot average as explained in note 8 above), and time = 1998 − 1900 = 98.

7. The standard error of estimate used in calculating the confidence interval was 0.211, measured in natural logs.

8. Readers with a keen statistical interest will note the existence of a potential problem in this regression model. As the dependent variable in the earlier regressions, flyaway cost—the predictor variable here—is subject to both measurement and other types of unsystematic error. The consequences of errors in a predictor variable are developed in virtually all econometrics texts—see, for example, Greene (1990, pp. 293–300). They may be summarized as follows: The small-sample parameter estimates obtained by the method of ordinary least squares (OLS) will be biased (not equal on average to the true parameter values), and the bias will not vanish as the sample becomes increasingly large. An approach that is frequently well suited for this situation

is estimation by the method of instrumental variables (IV).That method was employed here, with the ranks (from 1 to 18) of the observations on the cost variable serving as its instrument (Durbin, 1954). In this case, the OLS and IV estimators produced virtually identical results. For that reason, the issue was pursued no further.

9. This was suggested by William D. O'Neil, Vice President, Acquisition, Technology, and Systems Analysis Division, The CNA Corporation.

SYSTEMS ENGINEERING AND THE JOINT STRIKE FIGHTER: *THE FLAGSHIP PROGRAM FOR ACQUISITION REFORM*

Robert G. Struth, Jr.

The Joint Strike Fighter program, which aims to provide a new aircraft that will satisfy needs of the U.S. Navy, Air Force, and Marine Corps, the United Kingdom, and other non-U.S. services, is a challenging undertaking. Adding to the challenge is that it is being conducted under DoD's acquisition reform initiatives. Here we compare its progress to that of past aircraft programs.

The Joint Strike Fighter (JSF) program represents the largest potential aircraft contract for the U.S. Department of Defense (DoD) in the foreseeable future. It will provide replacement strike fighters for the U.S. Air Force, the U.S. Navy, and the U.S. Marine Corps, as well as for the United Kingdom and probably many other non-U.S. services. The objective of meeting the different needs of many services with variants of a single airplane is a very difficult challenge, especially when the number one consideration is affordability.

As part of the plan to achieve an affordable solution, the JSF program will be conducted under the DoD's acquisition reform initiatives begun in 1994. These initiatives mandate a new and innovative way of doing business, canceling many government military standards and specifications and stating the services' needs in performance-based terms. No longer will the government mandate compliance to military specifications with "design-to" guidance, requiring certain materials and processes. The government will simply state what it needs the JSF weapon system to perform and allow the contractor to provide the optimum solution based on a balance of technology and best commercial practices.

This article highlights the differences between the JSF program and past aircraft

programs. It concentrates on the application of best systems engineering practices and the use of performance-based specifications, and provides insights into how customer-contractor relationships will achieve the common goal of an affordable solution to the warfighter's needs.

The Program

The tactical aircraft modernization plans of the U.S. Air Force and Navy have something in common—the JSF. The competing industry developers, Boeing and Lockheed-Martin, are in the middle of assembling the first of two JSF concept demonstrator aircraft, which will undergo flight evaluations this year.

The JSF program aims to develop an affordable family of next-generation multirole attack aircraft with high commonality for the Air Force, Marine Corps, Navy, and U.S. allies. It has been described as a supersonic, single-engine, single-seat airplane; it's an F–16/F/A–18 class performer, but it's stealthy. The three JSF variants are: a conventional takeoff and landing (CTOL) replacement for the U.S. Air Force's F–16 to complement the F–22; a Navy aircraft carrier-based attack (CV) variant with extra stealth to complement the F/A–18E/F; and a short take-off and vertical landing (STOVL) replacement for the U.S. Marine Corps' AV–8B *Harrier* jump jet and F/A–18C/D aircraft and the U.K. Royal Navy's *Sea Harrier.* The Air Force may also buy some STOVL variants to replace its A–10s in the close air support role.

About 3,000 of the three variants are planned: the first will become operational around 2008. Exports could total another 2,000 aircraft over the life of the program. Following flight testing of their concept demonstrator aircraft in 2000, only one of the two competing industry teams will be selected the following year to continue into the engineering and manufacturing development (EMD) phase of the program, subsequently building those 5,000-plus airplanes.

Both Boeing and Lockheed-Martin will use their concept demonstrators to show the fundamental characteristics of their CTOL and CV variants, and prove out basic STOVL variant performance. The competitors, in particular, must demonstrate the commonality and modularity of their three variants, STOVL hover and transition, and low-speed handling qualities that are needed for carrier landings.

A key to high commonality among the three variants is the propulsion scheme chosen by each competitor to link its CTOL/CV and STOVL designs. Boeing's X–32 JSF uses a direct-lift system similar to the *Harrier*'s, with stowable Rolls-Royce lift nozzles on its Pratt & Whitney JSF119-614 engine, as well as small pitch, roll, and yaw nozzles fed from engine exhaust air. Lockheed Martin's X–35 design, for STOVL propulsion, uses its JSF119-611 engine to drive a separate Rolls-Royce Allison lift fan, located behind the cockpit, which blows cool air downward. It also uses a three-bearing swivel exhaust nozzle on the main engine and roll-control ducts in the wings.

Paths To Affordability

As noted on the JSF program's Internet website (http://www.jast.mil):

The focus of the program is affordability—reducing the development cost, production cost, and cost of ownership. The program is accomplishing this by facilitating the Services' development of validated, affordable operational requirements and by lowering risk by investing in, and demonstrating, key leveraging technologies and operational concepts prior to the start of the engineering and manufacturing development (EMD) phase of the JSF in 2001.

Development of the leveraging technologies by various firms has been funded under technology maturation contracts, the results of which benefit both Boeing and Lockheed Martin. All of the data will go to both teams, who are free to use any of this proven technology in their final proposals if it is, in fact, low risk and contributes to the affordability of the weapon system.

Operational Requirements

The scope of the JSF program's joint operational requirements development process has been unprecedented. Begun in 1994, it has involved the full-time participation of "warfighter" representatives, experienced pilots, logisticians, and maintenance officers assigned by each service to support the JSF program. No similar requirements document has ever been produced by warfighters with such a plethora of information on which to base decisions on requirements.

The services have a robust set of models and simulations with which they can look at generic performance levels for a JSF, coupled with associated cost estimates provided by industry and the program office. The goal is to balance costs with operational performance requirements and do tradeoffs to ensure that the requirements the Services are asking for will meet their needs—and make sure that the aircraft will come in at a cost that the Services' budgets can afford. The emphasis is on cost as an independent variable (CAIV), and the unit flyaway cost targets that the JSF program hopes to beat are $28 million for the CTOL variant, $35 million for the STOVL version, and $38 million for the CV variant (in fiscal year 1994 dollars).

"The scope of the JSF program's joint operational requirements development process has been unprecedented."

JSF as the Flagship Acquisition Reform Program

The JSF program is the first major aviation acquisition effort that emphasizes the acquisition reform initiatives first mandated by William Perry in 1994 as Secretary of Defense. The objective of these initiatives is to break the accelerating upward spiral of the cost of military aircraft programs (Figure 1) by streamlining the DoD's acquisition process. The central feature of these initiatives is the cancellation of thousands of DoD military standards and specifications (MIL-STDs and MILSPECs). These documents overspecified requirements, mandated "design-to"

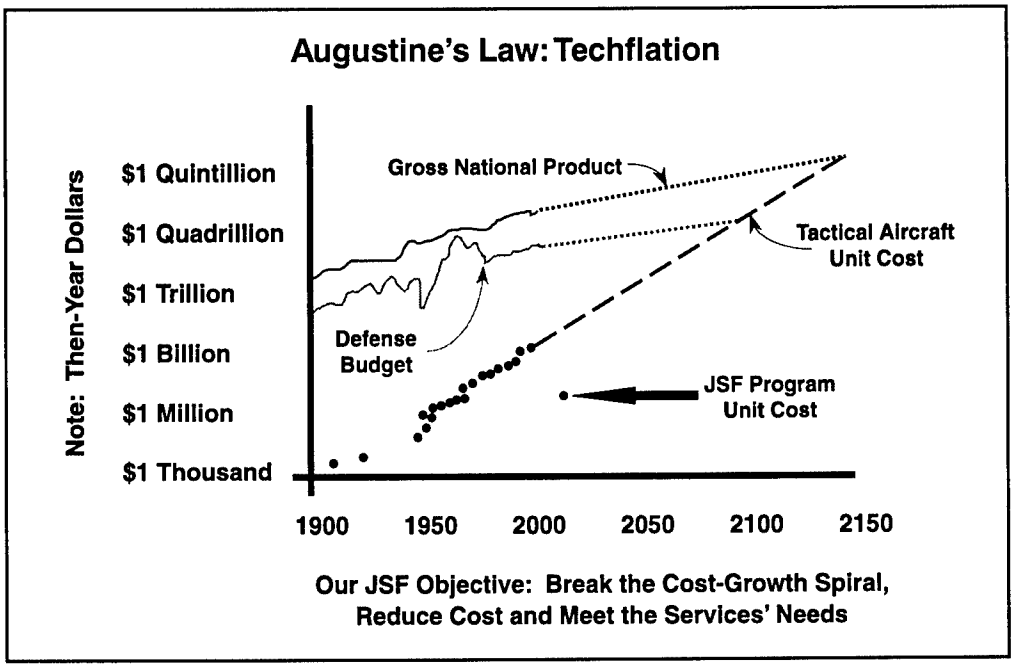

Figure 1. The JSF Objective: Break the Cost-Growth Sprial, Reduce Cost and Meet the Services' Needs

details, and limited the contractors' flexibility in providing an optimized product.

The key feature of the reformed process is performance-based specifications (PBS) (attributes shown in Figure 2), wherein the government states a need for a capability by specifying functional performance, the environment in which the system must operate, the interfaces to existing or planned systems, and the expected operating and support characteristics. PBS does not specify detail design requirements that lock the contractor into specific designs, does not specify requirements for materials, assemblies, or components, does not specify "how-to" or process standards.

An example: instead of specifying that the JSF have a radar and requiring specific design features such as power output, pulse repetition frequency, scan rate, etc., the government would specify a need to detect, track, and identify targets at tactically significant ranges. The contractor may or may not decide to use a radar to satisfy this need; there may be some other onboard (or offboard) sensor that may perform better and be more affordable. The point is that the contractor has the flexibility to use best design practices and leverage available technology in order to meet the need. Figure 2 summarizes some of the objectives that make the JSF program different.

To operate in this new PBS environment, the Joint Program Office (JPO) established a PBS working group (see Figure 3) in December 1996 to develop the JSF model specification. This group is made up of representatives from JPO, Boeing,

Government Objectives:

- Get warfighter and technologist together to enable leveraging cost-performance trades
- Apply technology to lower cost of the system not just increase its performance
- Adequately mature technology prior to entering EMD
- Solution must be joint
- Instigate/catalyze acquisition reform
- Develop system under extremely constrained cost and schedule goals

These objectives and internal management focus on "Thinking-X" led to a Boeing JSF streamlined and distributed Systems Engineering Organization.

Figure 2. Why JSF is Different

and Lockheed-Martin who have strong systems engineering backgrounds, especially in requirements development. They are charged with developing the model spec that shall:

- define system performance that meets the requirements defined in the Joint Interim Requirements Document/Joint Operational Requirements Document (JIRD/JORD);

DO

- Specify Functional Performance/Results
- Define the Environment in Which System Must Operate
- Define the System Interfaces
- Define the Operating and Support Characteristics
- Utilize Measurable and Verifiable Requirements

DO NOT

- Specify Detail Design Requirements that Lock Ktr into Specific Design
- Specify Requirements for Materials, Assemblies or Components...
- Specify "How-To" or Process Standards

Figure 3. Performance Based Specifications (PBS)

- include the minimum essential requirements necessary on contract for the government to manage the program;
- be included in the request for proposal (RFP) and tailored in the contractors' EMD proposals;
- be developed in a timely manner to support JSF scheduled events; and
- allow the government and contractor to minimize surprises in the "down-select" process.

The model spec is intended to concentrate on the key or critical performance requirements that would make or break the program, and would include only the performance minimums contained in the JIRD/JORD. The adjacent box lists the major attributes of the JSF model spec. The JIRD/JORD will also include desired "objectives" which the contractors may decide to design to in order to have a competitive advantage.

Now what this all means is that the JSF model spec, which will form the basis of the contract spec, will contain, as a goal, 150 to 200 requirements. Contrast this number with the more than 16,000 contractual requirements on the F/A-18E/F and more than 6,000 on the F–22. The model spec will be "contractor generic"—that is, the same for each competitor, as shown in Figure 5, and its development is paid for by the government during the concept demonstration phase.

Each contractor will develop a "JSF contract specification" specific to its design, which will capture all of the model specifications. However, contractors are be free to sign up to meet additional requirements if they feel it is to their competitive advantage. This contract spec, which will be provided in response to the RFP, will also contain the verification plan for ensuring that the requirements are achieved.

The JSF Specification Shall:

- Define the System Performance that Meets the Requirements Defined in the JORD
- Include the Minimum Essential Requirements (MERs) Necessary for the Government to Manage the Program
  - Concentrate on Key/Critical Performance Requirements
  - Relatively Limited Number of Requirements are Expected
  - Express Requirements at Highest Aggregate Level Practical
- Use Performance-Based Approach
  - State Required Results,
  - Not "How-to", Design Details/Solutions or Process Standards
- Be Included in the CFI and Tailored in the Contractor's E&MD Proposal

Figure 4. JSF Specification for EMD

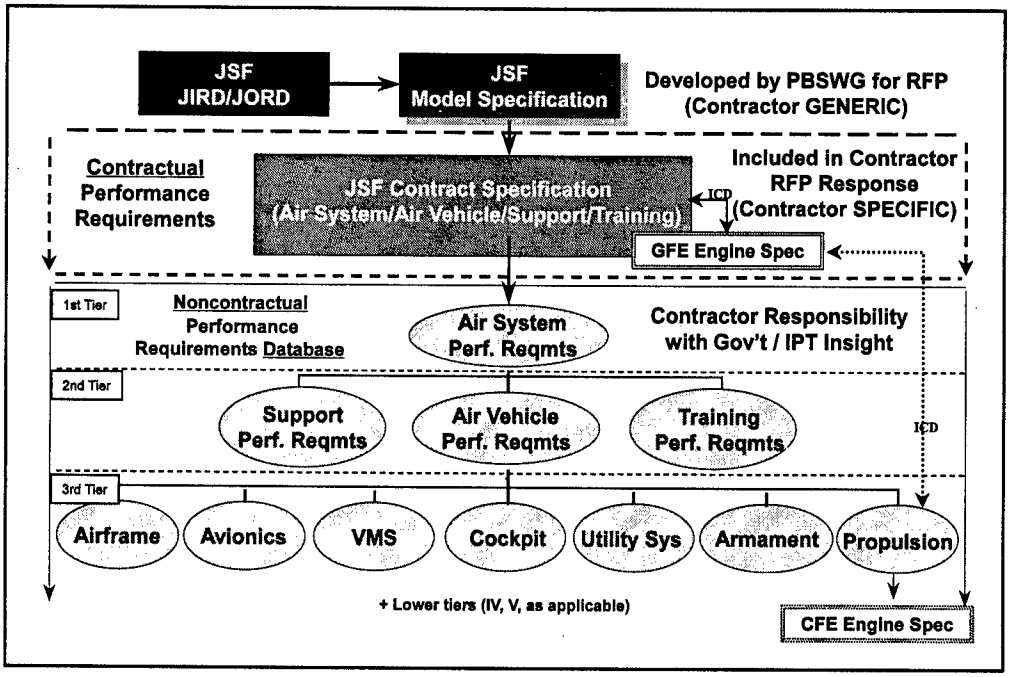

Figure 5.
The Program Develops a Performance-Based Specification Tree

- **What is "JSF Model Spec"?**
  - A Generic, Non-Contractor-Specific Format for Statement of Performance Requirements (Section 3 Only) in the EMD Solicitation (95% Solution)
  - RFP Solicitation Version Should Have No TBDs (= No Surprises)
  - Includes the Minimum Essential Requirements (MER) Necessary for the Government to Specify System Performance That Meets the Requirements Defined in the JORD
  - What is "Proposed JSF Contract Spec"?
  - The Contractor-Specific, Tailored Version of the JSF Model Spec Submitted in the Contractor's EMD Proposal (100% Solution)
  - All Section 3 Completed and Section 4 Completed with Proposed Verifications
- **What is "JSF Contract Spec"?**
  - The Agreed-to Document That Goes on Contract; Essentially the Same as the "Proposed JSF Contract Spec" with Final Verifications
  - Includes the Minimum Essential Requirements (MER) Necessary for the Government to Manage the Program and Receive the Desired Capability/Product

Figure 6. Specsplanation of Terms

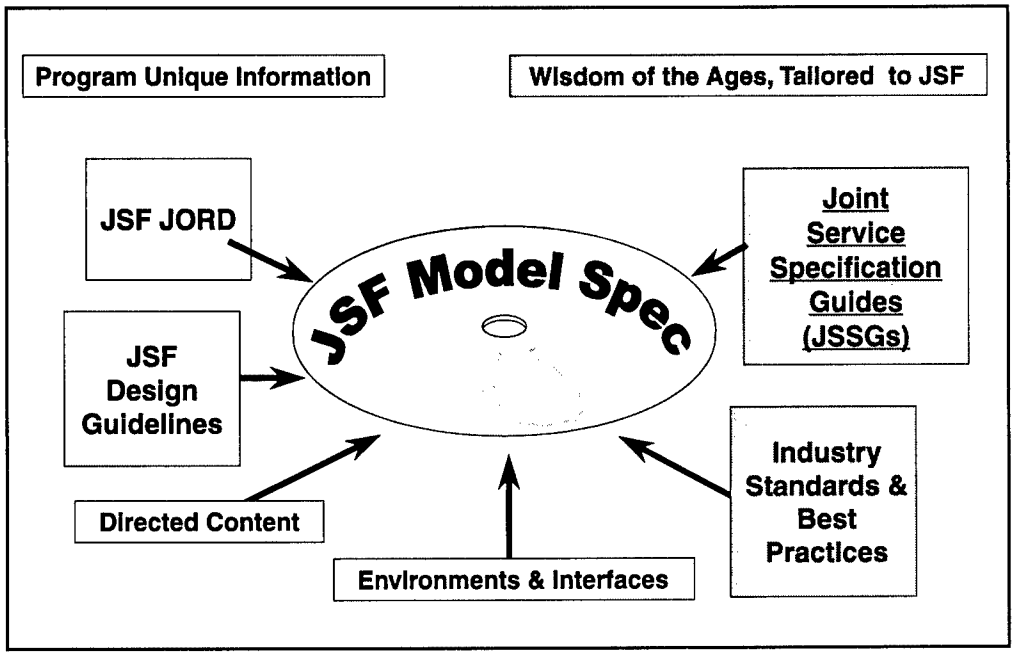

Figure 7. Program-Unique Specification

Note that in Figure 5 all of the supporting lower-tier specifications, which were on contract in past programs, will now be noncontractual items. In order to allocate requirements to the various product areas which make up the air system, all of these

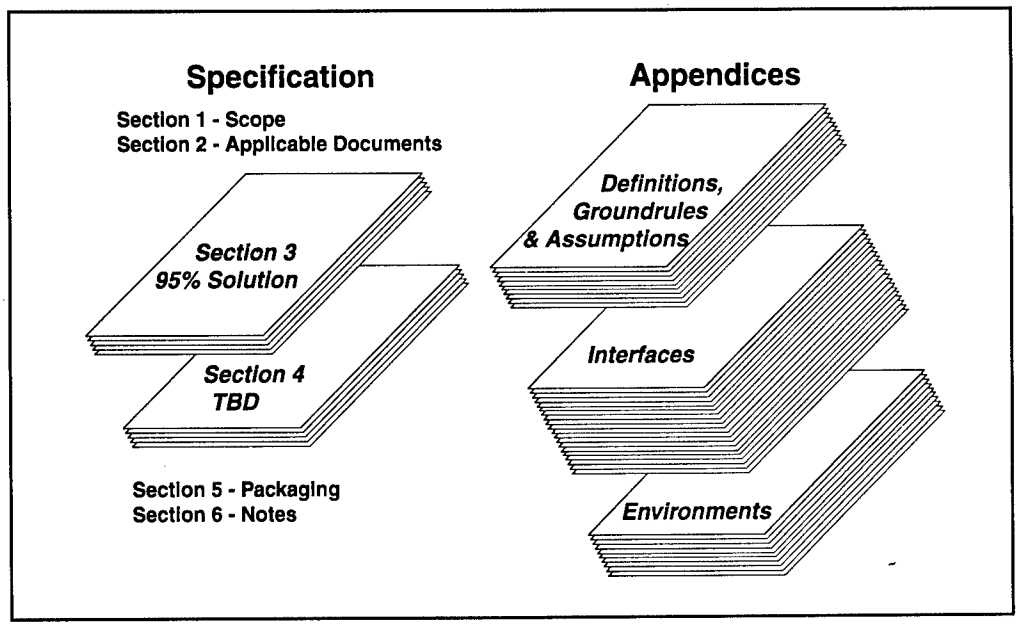

Figure 8. JSF Model Specification Structure

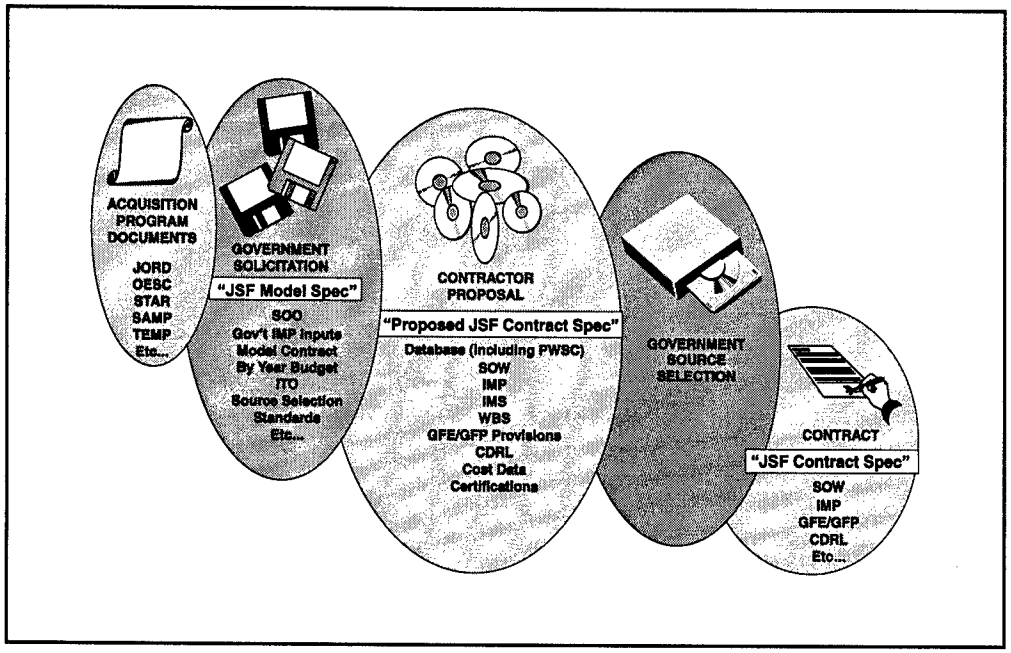

Figure 9. Technical Content from Requirements to Contract

lower-tier specifications must still be developed as on more traditional programs, the difference is now that they are not on contract, and the contractor is free to make design changes internally. In this way, trades of structures versus avionics systems, for

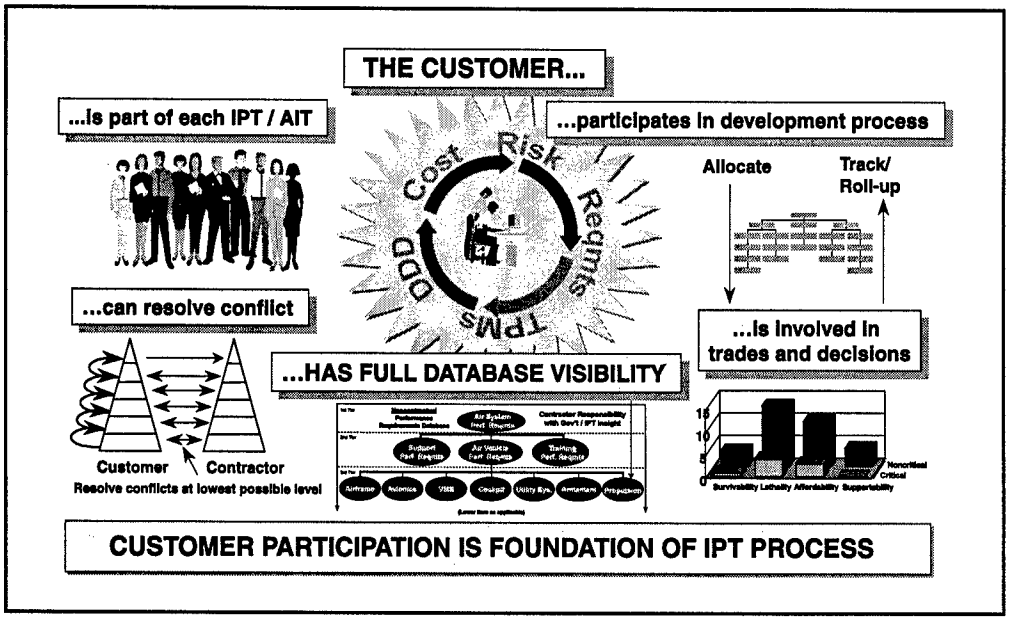

Figure 10. In Acquisition Reform, IPT Activities are Customer-Oriented

example, may be made in order to optimize the entire system with an eye toward performance and affordability.

This flexibility actually represents an increase in the difficulty of the contractor's job, because they are tasked to maximize creativity and best practices. The key to reducing cost and cycle time is that this flexibility means that when detail design changes are made at levels below the contract spec, contract changes are not required, therefore, contracts and legal personnel are not involved. The adjacent box ("'Specsplanation' of terms") summarizes the definitions of the model and contract specs.

Systems engineers lead both the creation of the model spec and each contractor's response to it. They coordinate the many inputs that influence the model spec (Figure 7), such as the JIRD/JORD, JSF design guidelines, directed content, environments and interfaces, Joint Service specification guides, industry standards and best practices, and the "wisdom of the ages, tailored to JSF."

Figure 8 shows the JSF model spec structure. Section 3 contains the limited set of very top-level requirements, and Section 4 (which when added will transform the model spec into a contract spec) will contain the associated verification schemes. The appendices will contain definitions, ground rules, and assumptions as well as the environments and interfaces required. However, the model/contract spec is only a small part of the entire RFP and response, as shown in Figure 9. The government solicitation will also include the statement of objectives, budget information, source selection standards, etc. And the contractor proposal will contain the statement of work, integrated master plan, work breakdown structure, etc. But the contract spec is the foundation of the entire effort.

- Minimum Essential Requirements to Manage the Program & Deliver Warfighter Capability /Product
  - Concentrate on Critical Requirements - KPPs, CPPs
  - Maximize Contractor's Responsiveness to Key Performance Requirements
  - Maximize Available Trade Space
  - Class I Configuration & Change Management Burden Minimized
- Enables Optimum CAIV Implementation
  - Promotes Maximum Flexibility in Addressing Affordability via Performance vs. Cost Trades
- Maximum Contractor Flexibility in Product Development and Subcontractor/Vendor Relationships
- Innovative Specification Approach supports JSF as Acquisition Reform Flagship Program

Figure 11. Acquisition Reform Reduces Cost and Cycle Time

Of course, as with any new process, there will be reluctance to change, both on the part of the government customer and the contractor. Figure 10 shows the key to the success of this new way of doing business. The customer must have daily access to and participate in the systems engineering processes such as risk manage-ment, trade studies management, configuration management, technical performance metric evaluation and tracking, and requirements and verification development.

The government IPTs must have complete confidence that, even in the absence of the "hammer" of lower-tier specs, the contractor will meet their needs. This is critical: When the contract spec only says, "the JSF shall be compatible with CVN-68 *Nimitz*-class and subsequent carriers," the government customer must be convinced that the contractor understands what this means, can capture the essential aspects of that requirement, allocate that requirement down through the lower-tier teams, design to the requirement, and, most important, provide verification that the requirement will be met.

Further, this acquisition reform process will only be optimized when the prime contractors promote a relationship with their teammates and subcontractors that focuses on performance-based specifications and the other aspects of acquisition reform.

The Challenge

Acquisition reform is intended to reduce cost and cycle time by minimizing contract changes, as shown in Figure 11. This is achieved by specifying only the minimum essential requirements to manage the program and deliver warfighter capability. The contract specifications must concentrate on only the key and critical performance parameters, which define the program. This will maximize the contractor's responsiveness to these parameters by maximizing the available trade space, and minimizing the contract and configuration management burden.

This approach, using PBS, enables optimum CAIV implementation and promotes maximum flexibility in addressing affordability via performance versus cost trades. It maximizes contractor flexibility in product development and subcontractor and vendor relationships and the ability to take advantage of best commercial practices.

Systems engineers lead the effort to meet the challenge of acquisition reform, and their development of an innovative specification approach supports JSF as the acquisition reform flagship program.

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THE RELATIONSHIP BETWEEN LEADER-MEMBER EXCHANGE AND COMMITMENT AND ORGANIZATIONAL CITIZENSHIP BEHAVIOR

Yolanda B. Truckenbrodt

The leader-member exchange theory of leadership, which focuses on the two-way relationship between supervisors and subordinates, aims to maximize organization success by establishing positive interactions between the two. Results of the study detailed here suggests that a significant relationship exists between the quality of the supervisor-subordinate relationship and subordinates' commitment and altruistic organizational citizenship behavior. Recommendations are presented.

The concept of leadership has attracted an extensive body of literature, ranging from fiction and biographies to how-to manuals and scientific investigation. The influence of leadership is important in the military, politics, government, academia, and, indeed, in every profit or nonprofit organization. Leadership has been widely conceptualized and tested in behavioral psychology, business management, and military studies. The numerous research studies on leadership are hard to classify into categories of approaches (traits, behaviors, and styles).

The difficulties are illustrated by Stogdill (1974), who concludes that "There are almost as many different definitions of leadership as there are persons who have attempted to define the concept" (p. 7). Early research has defined leadership in terms of innate individual traits: some people are somehow born with an inborn quality to lead. Later research shifts emphasis on two behavioral functions of leaders: initiating structure (task direction) and consideration (employee-centered). Subsequently, Fiedler's contingency theory is introduced, wherein leaders exercise different leadership "styles" depending on the group-task situation and nature of the interpersonal relations between the leader and the followers.

But these early leadership theories have not been completely satisfactory, and the past two decades have produced several other theories. One of the more recent is leader-member exchange (LMX) theory; its central focus is the relationship and interaction (a dyadic exchange) between the supervisor and the subordinate, as opposed to the traits, behaviors, situational styles of the leader, or any other variables.

To survive the challenges of the highly competitive and ever-changing global market of the 21st century, corporations need to understand LMX and how it contributes to the survival and profitability of business operations. The research detailed here investigates the quality of the relationship between LMX on subordinate's commitment and organizational citizenship behavior (OCB). The conclusions might help policy-making management executives and human resource specialists to support initiatives such as employee training and leadership career development, and help positively shape the organization's future.

Previous studies examine the construct of citizenship behavior based on leaders' reports. Wayne and Green (1993) investigate the effects of LMX on employee citizenship behavior from the standpoint of the member rather than the leader. The research extends and builds on Wayne and Green's study by examining the relationship between LMX and the consequences of OCB, with the member as the source.

Leader-Member Exchange

Leaders treat subordinates differently at varying degrees and levels contingent on whether the latter are part of the in-group (high-quality relationship) or out-group (low-quality relationship) (Graen and Scandura, 1987). The theory asserts that leaders do not interact with subordinates uniformly (Graen and Cashman, 1975) because supervisors have limited time and resources.

"In-group" subordinates perform their jobs in accordance with the employment contracts and can be counted on by the supervisor to perform unstructured tasks, to volunteer for extra work, and to take on additional responsibilities. Supervisors exchange personal and positional resources (inside information, influence in decision making, task assignment, job latitude, support, and attention) in return for subordinates' performance on unstructured tasks (Graen and Cashman, 1975). As a result, research shows mutual trust, positive support, informal interdependencies, greater job latitude, common bonds, open communication, high degree of autonomy, satisfaction, and shared loyalty exist (Dansereau, Graen, and Haga, 1975; Dienesch and Liden, 1986; Graen and Uhl-Bien, 1995).

In contrast, subordinates who perform only in accordance with the prescribed employment contract are characterized as "out-group" with limited reciprocal trust and support, and few rewards from their supervisors (Deluga, 1998). The exchange between the superior-subordinate (dyad), a two-way relationship, is the unique basic premise and the unit of analysis of LMX.

Commitment

Commitment is an attitude of company loyalty exhibited by employees. It stems from the employees' combined belief that

the goals, objectives, and values of the organization are congruent with their own. As noted by Mowday, Porter, and Steers (1982), commitment is the "relative strength of an individual's identification with and involvement in the organization" in terms of values and goals. Ostroff (1992) reports that committed employees are associated with better organizational performance, have a low turnover rate, and have low absenteeism.

It is essential, therefore, that supervisors understand the significance of building a positive relationship with their respective subordinates. The supervisor should clearly state the goals, mission, and vision of the organization and, most important, the role each of the subordinates contributes to the business operations. An organizational culture that provides such awareness instills a sense of belonging and a positive feeling of identification with the organization, thus enhancing the subordinate's commitment to the organization.

Organizational Citizenship Behavior

Smith, Organ, and Near (1983) report a two-dimensional model of OCB: altruism and general compliance (also known as conscientiousness). Altruism is an individual's personal behavior—for example, being cooperative, helpful, and other instances of extra-role behavior (Smith, Organ, and Near, 1983). It is a behavior performed in helping a specific coworker, a customer or a supervisor, not normally expected of the employee since it is not part of the employment contract. Examples are being accommodating to new employees, sitting in for a sick coworker, or assisting supervisors and others.

Compliance is another behavior employees are expected to exhibit (e.g., arriving to work on time, not taking too many coffee breaks, taking only the required lunch time, or not leaving early). Organ (1988) and Schnake (1991) believe citizenship behaviors, although discretionary, are necessary for they promote effective functioning of the organization. In a study of 218 people working in a Northeast paper mill, Podsakoff et al. (1997) find a positive correlation between citizenship behavior and the organization's output.

"Altruism is an individual's personal behavior—for example, being cooperative, helpful, and other instances of extra-role behavior."

Citizenship behavior improves the effectiveness of the organization by the high degree of work group performance in terms of quantity and quality of work. Settoon, Bennett, and Liden (1996) postulate that in-group members receive formal and informal rewards from their subordinates. In exchange, the members seek out extra-role situations in the form of providing citizenship behavior to the supervisors who, in turn, give more reciprocal support and opportunities to the members. This cycle of "helping" behavior for mutual attainment of goals helps further intensify the quality of the supervisor-subordinate exchange (Scandura and Graen, 1984).

Additionally, Deluga (1994) reports a positive relationship between employee OCB and the quality of LMX in a study of 86 subordinate-supervisor dyads from a highly diversified organizational sample.

Likewise, a field study by Wayne and Green (1993) supports the relationship between LMX and employee citizenship behavior, specifically as it relates to altruism.

Methods

Sample

The sample consisted of 204 full-time employees in a highly specialized, information technology solutions company. The company acts as a support contractor and provides engineering, design, technical assistance, and systems and software information in weapon systems acquisition to various program management offices in a military installation in the Midwest.

All managers who supervise one to three subordinates were selected to participate. From those who supervise more than four subordinates, a simple random sample of four employees were asked to participate. A total of 162 subordinates were asked to answer the survey. Those subordinates answered to 59 supervisors; 17 of them were randomly selected to fill out a survey questionnaire as subordinates. The response rate of the supervisors was 61 percent; 57 percent of the subordinates responded.

"The sample consisted of 204 full-time employees in a highly specialized, information technology solutions company."

The completed questionnaires were then paired between the subordinate's questionnaire and that of his or her supervisor to form a dyad. There were 126 usable matches or 63 dyads, yielding a response rate of 78 percent.

Procedures and Data Collection

Survey questionnaires reached the participants via the company's internal mail system. A pre-addressed return envelope provided by and addressed to the researcher was included in the questionnaire package. Enclosed with the supervisor's survey was a code list with the corresponding name(s) of the employee(s), and the survey was coded with a number so that supervisor and subordinate responses were matched (paired dyads) for statistical analyses. Similarly, the subordinate's survey was identified with a number corresponding to the supervisor's code list.

Measures

Three extensively pretested research instruments were used in the study: the leader-member exchange (LMX-7) scale for supervisors and subordinates, the organizational commitment questionnaire (OCQ), and the OCB scale. Table 1 summarizes the instruments. In the Liden et al. (1997) meta-analysis review of 48 studies, 18 studies cited the LMX-7 scale as the instrument of choice to measure LMX. The leader form consists of seven questions (Including "How well do you know this employee's problems?" "How well do you recognize this employee's potential?" "How would you characterize your working relationship with this employee?"). The member form is the same basic set of questions with the employee as the referent.

The OCQ is a widely used instrument to measure employees' commitment ("I

Table 1. Summary of Study Instruments

Name of Instrument	Description	Variable Examined	Source of Data
LMX-7 Scale for Supervisor (MLMX) (Scandura and Graen, 1984)	7 questions, designed for supervisors on a 5-point multiple choice range	Leader-member exchange	Supervisor evaluates relationship with his/her Subordinate (dyadic exchange)
LMX-7 Scale for Subordinate (ELMX) (Scandura and Graen, 1984)	7 questions, with subordinate as referent, on a 4-point scale	Leader-member exchange	Subordinate evaluates relationship with his/her Supervisor (dyadic exchange)
Organizational Commitment Questionnaire (OCQ) (Mowday et al., 1982)	9 positively worded items, on a 7-point Likert-type scale	Organizational commitment	Subordinate (self-reports)
Organizational Citizenship Behavior (OCB) Scale (Smith et al., 1983)	16 items: 3 negatively worded on a 5-point range with subscales: altruism (6-item) and compliance (8 item)	Organizational citizenship behavior and the subscales of altruism and general compliance	Subordinate (self-reports)

would accept almost any type of job assignment in order to keep working for this organization." "I am proud to tell others that I am part of this organization." "This organization really inspires the very best in me in the way of job performance." "I really care about the fate of this organization."). The response range is from "strongly disagree" (1), "neither disagree nor agree" (4) , to "strongly agree" (7).

The OCB scale contains 16 questions with a five-point Likert scale containing the following anchors: "never" (1), "seldom" (2), "occasionally" (3), "often" (4), "almost always" (5). The OCB has two subscales. The first is altruism (e.g., helps others who have been absent; volunteers for things that are not required; orients new people even though it is not required; helps others who have heavy workloads). The second is compliance (e.g., punctuality; attendance at work is above the norm; gives advance notice if unable to come to work; does not take extra breaks; does not spend time in idle conversations).

ANALYSES

Table 2 summarizes the data analyses showing the instruments used as well as the statistical methods to answer the research questions and test the null hypotheses, with a criterion for rejection set at $p < 0.05$. A two-tailed test of significance is also computed to test whether the correlation coefficients are significantly different from zero.

Table 2. Summary of Data Analyses

Research Questions	Null Hypotheses	Instruments	Statistical Treatments	Test Statistics	Variables Independent/Dependent
Relationship between LMX and organizational commitment?	Ho_1 and Ho_3	LMX-7 scale (ELMX) and (MLMX) and OCQ	Correlation analysis and analysis of variance (ANOVA)	*F* test	LMX/OC (QSCORE)
Relationship between LMX and organizational citizenship behavior?	Ho_2 and Ho_4	LMX-7 scale (ELMX) and (MLMX) and OCB scale	Analysis of variance (ANOVA)	*F* test	LMX/OCB (BTOTAL) and subscales: ALTRUISM COMPLNC

FINDINGS

DESCRIPTIVE STATISTICS

The manager LMX-7 scale (MLMX) contains seven questions having a five-point Likert scale response format tailored to each question, and the employees LMX-7 scale (ELMX) with a four-point Likert scale. Both LMX-7 scales are scored by summing up the responses for all questions, respectively. The range of the total score for manager (MTOTAL) is 7 to 35. A high score represents a more positive relationship with the subordinate, as perceived by the employee's manager. The range of the total score for employee (ETOTAL) is 7 to 28. A high score represents a more positive relationship with the supervisor, as perceived by the employee.

The OCQ is scored by summing up responses for all questions (QTOTAL) and then dividing the number of questions (QSCORE) by nine to derive a summary indicator of commitment. The possible range of QTOTAL is 9 to 63, and the possible range of QSCORE is 1 to 7. A high score represents a high degree of organizational commitment.

The OCB scale is scored by summing up responses for all questions (BTOTAL). The possible range of BTOTAL is 16 to 80. A high score represents a high display of organizational citizenship. The OCB scale contains two subscales which describe unique attributes of citizenship behavior: altruism and compliance. The altruism (ALTRUISM) subscale is calculated by summing up responses to questions 1, 3, 5, 7, 12, and 13 (range, 6 to 30). The compliance (COMPLNC) subscale is calculated by summing up responses to questions 2, 4 (reversed), 6, 9, 10 (reversed), 11, 14 and 16 (range is 8 to 40). Table 3 demonstrates a high level of internal consistency and reliability of the scales, with the exception of COMPLNC subscale.

Table 4 gives additional descriptive statistics, *n,* means, and standard deviations for all the scales totals.

Table 3.
Coefficient Alpha (Test of Internal Consistency and Reliability)

Test or Subtest	Coefficient
MLMX	0.747
ELMX	0.877
OCQ	0.884
OCB	0.718
Altruism	0.746
Compliance	0.560

RESULTS

This study investigated two research questions and tests four null hypotheses.

Research question 1. Is there a relationship between the quality LMX and organizational commitment?

Ho_1: There is no significant positive relationship between high-quality LMX and high organizational commitment.

Ho_3: There is no significant positive relationship between low-quality LMX and low organizational commitment.

The quality of LMX is defined as "high" when the total (sum) score for

Table 4. Summary Statistics

Variable	n	Mean	Standard Deviation
MTOTAL	63 dyads	28.714	3.289
ETOTAL	63 dyads	21.984	4.195
QTOTAL	63 dyads	47.206	9.366
QSCORE	63 dyads	5.245	1.041
BTOTAL	63 dyads	60.667	7.007
ALTRUISM	63 dyads	22.905	3.622
COMPLNC	63 dyads	30.746	4.337

MLMX (MTOTAL) and the ELMX (ETOTAL) are both greater than or equal to 24. Otherwise, the quality of the LMX is defined as "low." Since MTOTAL (range 7 to 35) and ETOTAL (range 7 to 28) have dissimilar scales, this analysis takes into account the disparate ranges of the scale and the correlation between QSCORE (organizational commitment questions) and ETOTAL. A new variable, LMX1, is the mean of MTOTAL and ETOTAL. Thus, high-quality LMX is defined as LMX1 greater than or equal to 24, low-quality is defined as LMX1 less than or equal to 23.

The analysis of variance (ANOVA) shows a p value (0.0429) commensurate with a significant relationship between quality of LMX and organizational commitment. The mean QSCORE for low-quality LMX is 4.81; the mean for the high-quality LMX is 5.41. The difference between these means, 0.59 (95 percent confidence interval [0.02, 1.17]), indicates with 95 percent confidence that, on average, those individuals with high level of LMX scored between 0.2 and 1.17 points higher on the QSCORE than those with low LMX. Therefore, null hypotheses Ho_1 and Ho_3 are rejected.

"Another interesting area for exploration would be to examine if a gender difference exists in reporting LMX."

Research question 2. Is there a relationship between the quality of LMX and OCB?

Ho_2: There is no significant positive relationship between high-quality LMX and high OCB.

Ho_4: There is no significant positive relationship between low-quality LMX and low OCB.

The ANOVA results show a p value (0.0237) for the dependent variable BTOTAL, providing sufficient evidence of a significant relationship between quality of LMX and OCB. The mean BTOTAL for low-quality LMX is 57.41; the mean for the high-quality LMX is 61.87. The difference between these means, 4.46 (95 percent confidence interval [0.61, 8.30]), indicates with 95 percent confidence that, on average, those individuals with high-quality LMX scored between 0.6 and 8.3 points higher on the OCB than those with low-quality LMX.

The p value (0.0047) for the dependent variable ALTRUISM indicates there is a significant relationship between quality of LMX and altruistic citizenship behavior. The mean ALTRUISM score for low-quality LMX is 20.82; the mean for the high-quality LMX is 23.67.

The p value (0.2784) for the dependent variable COMPLNC shows that insufficient evidence is present to prove a significant relationship between quality of LMX and compliant citizenship behavior. The analysis supports rejection of null hypotheses Ho_2 and Ho_4, lends partial support for the altruism subscale, and fails to support the compliance subscale.

Recommendations and Conclusuions

Future Research

A similar study should be conducted in a federal agency with civil service employees to compare the findings of the results. Another interesting area for exploration would be to examine if a gender difference exists in reporting LMX. In addition, other variables that might add depth to the descriptive statistics are the demographic data of length of employment and age, which could be important factors in determining a subordinate's sense of commitment and display of citizenship behavior.

Conclusions

Organizations are always faced with the increasing threat of domestic and global competition in this fast-changing technological world. The study suggests that the quality of exchange relationships affect subordinates' commitment and good will. Since LMX is positively correlated with turnover (Ferris, 1985), support for innovation (Scott and Bruce, 1994), performance (Wayne, Shore, and Liden, 1997), and productivity (Graen, Novak, and Sommerkamp, 1982), it is important for organizations to initiate sound developmental programs in order to attain business success. The following recommendations are offered for practical applications.

- Human resource managers and developmental specialists should conduct leadership training for all their employees. For the supervisors, leadership training that emphasizes the importance of mentoring, human relations skills, joint development of goals, and effective interpersonal communications would be helpful. Career planning and development seminars and workshops would benefit subordinates.

- Group interaction is a practical area in which to encourage high-quality exchange relationships. Team-building programs such as employee of the month, branch or division of the year, or three-day weekend passes reward employee performance, increase group morale, and improve office effectiveness.

- Building a corporate culture in which open two-way communication occurs at all levels is highly encouraged.

- Research literature states that organizational commitment is defined as a subordinate's identification with the mission, goals, and vision of the organization. Supervisors have the responsibility to emphasize to their subordinates their link and contribution to the success of the organization. Team meetings create a team environment where all the players are working toward jointly developed common goals.

- Supervisors are agents for change and act as role models and positive influences on their subordinates. As such, supervisors should pay particular attention to personal judgment not based on merit or performance, which is harmful to any success of business operations. Supervisors should provide equal training and career development plans to all subordinates, and recognize each employee's potential and capabilities to encourage an organizational culture

of growth and innovation. Subordinates should be afforded self-development training to increase their knowledge, skills, and self-confidence on the job.

- Supervisors should actively encourage subordinates to provide feedback and vice-versa. A plan of action, followup, and progress reports should also be established during feedback sessions. Open communication is necessary to establish a sense of trust in the exchange relationship.

Management might dismiss the findings and implications of this study as "touchy-feely." Yet the quantitative results of this and previous studies suggest that the quality of exchange relationships is significant, and organizations should address these areas, and strive to provide an environment wherein high-quality exchange relationships can thrive. The study suggests that improving the quality of LMX will increase subordinates' sense of commitment and citizenship behavior; development and maintenance of a mature dyadic relationship will benefit not only the supervisors and the subordinates, but also the organization as a whole in the achievement of organizational growth and success.

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References

Dansereau, F., Jr., Graen, G., Haga, W. J. (1975). A vertical dyad linkage approach to leadership within formal organizations—a longitudinal investigation of the role making process. *Organizational Behavior and Human Performance, 13,* 46–78.

Deluga, R. J. (1994). Supervisor trust building, leader-member exchange and organizational citizenship behaviour. *Journal of Occupational and Organizational Psychology, 67,* 315–326.

Deluga, R. J. (1998). Leader-member exchange quality and effectiveness ratings: The role of subordinate-supervisor conscientiousness similarity. *Group and Organization Management, 23,* 189–216.

Dienesch, R. M., & Liden, R. C. (1986). Leader-member exchange model of leadership: A critique and further development. *Academy of Management Review, 11,* 618–634.

Ferris, G. R. (1985). Role of leadership in the employee withdrawal process: A constructive replication. *Journal of Applied Psychology, 70,* 777–781.

Graen, G., & Cashman, J. F. (1975). A role-making model of leadership in formal organizations: A developmental approach. In James G. Hunt & Lars L. Larson (Eds.). *Leadership frontiers* (pp. 143–165). Kent, OH: Kent State University Press.

Graen, G. B., Novak M., & Sommerkamp, P. (1982). The effects of leader-member exchange and job design on productivity and satisfaction: Testing a dual attachment model. *Organizational Behavior and Human Performance, 30,* 109–131.

Graen, G. B., & Scandura, T. A. (1987). Toward a psychology of dyadic organizing. In B.M. Staw & L. L. Cummings (Eds.). *Research in organizational behavior* (pp. 175–208). Greenwich, CT: JAI Press.

Graen, G. B., & Uhl-Bien, M. (1995). Relationship-based approach to leadership: Development of leader-member exchange (LMX) theory of leadership over 25 years: Applying a multi-level multi-domain perspective. *Leadership Quarterly, 6*(2), 219–247.

Liden, R. C., Sparrowe, R. T., & Wayne, S. J. (1997). Leader-member exchange theory: The past and potential for the future. *Research in Personnel and Human Resources Management, 15,* 47–119.

Mowday, R. T., Porter, L. W., & Steers, R. M. (1982). *Employee-organization linkages: The psychology of commitment, absenteeism, and turnover.* New York: Academic Press.

Organ, D. W. (1988). *Organizational citizenship behavior: The good soldier syndrome.* Lexington, MA: Lexington Books.

Ostroff, C. (1992). The relationship between satisfaction, attitudes, and performance: An organizational-level analysis. *Journal of Applied Psychology, 77,* 963–974.

Podsakoff, P. M., Ahearne, M., & MacKenzie, S. B. (1997). Organizational citizenship behavior and the quantity and quality of work group performance. *Journal of Applied Psychology, 82,* 262–270.

Scandura, T. A., & Graen, G. B. (1984). Moderating effects of initial leader-member exchange status on the effects of a leadership intervention. *Journal of Applied Psychology, 69,* 428–436.

Schnake, M. (1991). Organizational citizenship: A review, proposed model, and research agenda. *Human Relations, 44,* 735-759.

Scott, S. G., & Bruce, R. A. (1994). Determinants of innovative behavior: A path model of individual innovation in the workplace. *Academy of Management Journal, 37,* 580–607.

Settoon, R. P., Bennett, N., & Liden, R. C. (1996). Social exchange in organizations: Perceived organizational support, leader-member exchange, and employee reciprocity. *Journal of Applied Psychology, 81,* 219–227.

Smith, C. A., Organ, D. W., & Near, J. P. (1983). Organizational citizenship behavior: Its nature and antecedents. *Journal of Applied Psychology, 68,* 653–663.

Stogdill, R. M. (1974). *Handbook of leadership: A survey of theory and research.* New York: The Free Press.

Wayne, S. J., & Green, S. A. (1993). The effects of leader-member exchange on employee citizenship and impression management behavior. *Human Relations, 46,* 1431–1440.

Wayne, S. J., Shore, L. M., & Liden, R. C. (1997). Perceived organizational support and leader-member exchange: A social exchange perspective. *Academy of Management Journal, 40,* 82–111.

OPINION

GOVERNMENT CONTRACTING PATHOLOGIES

Robert E. Lloyd, CPCM

While it is nice to see federal contracting agencies glowing with expectant self esteem over the bright future that reform legislation and regulation seem to promise, it may be more useful to lay them down on the couch and explore a few of the pathologies that may yet hinder them from becoming ideal acquisition offices.

Federal officials have promoted various improvement projects by advocating a best practices approach to acquisition reform. Emphasizing good news may be informative; but an alternative view—one which examines commonly found problems as object lessons—may be equally useful. Despite claims that the recent enactment of necessary reform legislation and regulation now leaves only implementation to complete the job, many intractable difficulties remain. Some of the dilemmas encountered in contracting offices are better considered as pathologies to be treated in a clinical sense if the ills of federal contracting are to be cured.

The literature of public administration has occasionally used the term "pathology" to describe the actions of humans in federal agencies. Downs (1967) was one of the first to describe life inside federal agencies in terms of defective systems and bizarre personality types. Bennis (1970) also emphasized the aberrant aspects of government work. Hummel (1982) likewise regarded work in federal agencies in terms of clinical psychological dysfunction due to the damaging effects of working in a bureaucratic environment. Contemporary analysts have discussed the problem of "latent pathogens" in an organization, such as poor design, poor training, and poor procedures which make mistakes inevitable (Klein 1998, p. 273)

Only in the past few years have some initial steps been taken to extend this type of examination directly to government contracting. Kelman (1990) focused on fear of discretion as a factor contributing to inadequate performance in government contract management. Muczyk (1998) describes "bureaupathologies" as a key obstacle to acquisition reform. The federal contracting process would profit from further application of this type of analysis.

Here we discuss several pathological conditions presented to track the sequence of the contracting cycle. The goal is to

answer the question: "What's keeping federal contracting from working better?" Through this sort of contrarian analysis I hope to demonstrate that government contracting as a system has a long way to go before we can claim that true reform has occurred.

The Budget Divining Rod: Who's on First?

Symptoms. In any given month of the year, program managers and contracting offices must be concerned with three different budgets. For example, assume this is September. Contracting and program offices are characterized by manic behavior, preoccupied with obligating funds for the soon-to-expire fiscal year's budget (first base).

Yet these offices must also be concerned with the looming start of the next fiscal year, with its separate budget (second base). Even if one can juggle those two balls at once, the budget for the fiscal year starting 13 months from now must soon be prepared, for it will be requested in just a few weeks (third base).

Agencies display confusion about priorities. As a result, poor spending decisions and sloppy contracting practices occur. Bad contract awards are made in the haste to spend money, and money that would have been spent more wisely is not, because of future budget uncertainties.

Diagnosis. Most humans cannot effectively manage three budget years at the same time. Only a soothsayer might predict the course of future budgets and funding patterns. The problem is information overload on budget matters and maximum uncertainty as to future funding. It is unrealistic to expect rationality in annual budget processes. Recent legislation authorizing severable service contracts to cross fiscal years (implemented in the Federal Acquisition Regulation (FAR) 32.703-3) is a useful band-aid but fails to get at the root of the problem.

Treatment. Congress should enact legislation treating this problem by adopting multiyear funding. Multiyear budgeting, and the appropriations to go with it, would be a useful palliative for the symptoms of federal budget woes as reflected in contracting offices.

Firm Requirement, No Money: A Solomonic Dilemma

Symptoms. The program office informs the contracting office that a large contract for a new program will need to be awarded this fiscal year. There is only one problem: Congress has not yet made available any money for the program. Still, the program office is certain that a large amount of money will be forthcoming, and the program is so important that it must go forward regardless of how late the money arrives.

The contracting office diligently attempts to serve its customer by carrying the contract up to the point of award, only to find that no money is forthcoming, or it will be provided in another fiscal year. Disillusioned, the contracting office feels it has been "had." Contracting officers have wasted resources that should have been devoted to other important projects that were properly funded.

Diagnosis. Irreconcilable uncertainty has created a no-win situation. To begin the procurement process now is to risk

wasting considerable resources on an effort that may never come to fruition if Congress decides not to provide funding. To refuse to begin the procurement process now is to risk having to award a contract in madcap fashion, if the money becomes available late in the fiscal year.

Treatment. The prescription for this dilemma is for contracting offices to stand firm and not take on this type of assignment. To do otherwise is simply to create incentives for poor program management and irresponsible behavior by Congress.

If a program is important, it must be timely and properly funded and managed. Anything less simply promotes bad government or brings into question the validity of the program. While this treatment may not fit within some readers' notions of customer service, if contracting officials attempted to do the same thing, program officials would laugh. There is no way to "split the baby." Something must give.

Advance Acquisition Planning: The Myth of Sisyphus

Symptoms. Program offices give lip service to the notion of advance acquisition planning. Program offices submit a handful of plans that do not represent a substantial portion of their contracting budgets. The plans are neither complete nor useful to the contracting office in planning future workload. The age-old problem of unexpected program office requirements clogging the contracting office continue, contributing to poor contracting practices.

Diagnosis. Determine whether program offices really understand what advance acquisition planning is. If advance acquisition plans are not useful, assess whether milestone plans for individual contracts, prepared after receipt of a funded procurement request, are sufficiently effective to deliver good contracts. Current laws on competition and small business both require advance acquisition planning, most recently mandating that each agency issue a forecast of upcoming contracting opportunities. Given the budget woes noted above, this forecast should not be relied on as a source of comprehensive, accurate information.

Treatment. None. This is a problem endemic to the federal government. No known treatment has proved effective. The laws on this subject would profit from some revision, especially the law requiring a small business forecast (15 United States Code (U.S.C.) 637[a][12][C)]), as it can very easily be misleading to small businesses. A bold agency may wish to process a class deviation from FAR Part 7 to eliminate the tired annual call for advance acquisition plans and replace it with merely individual milestone plans for specific contracts once they are funded.

"If a program is important, it must be timely and properly funded and managed."

Ratification: Not an Acquisition Strategy

Symptoms. Program offices, frustrated by dealing with what they consider to be unresponsive contracting offices, seriously consider making unauthorized commitments

to get what they need. Comments overheard in government cafeterias include: "Yeah, I know I'm supposed to send this to procurement, but then it won't get done on time or the way I want it. I'd rather tell the contractor to start work now, and ask for forgiveness later." Unauthorized commitments are routinely ratified, with little or no consequence even for repeat offenders.

Diagnosis. This illness may be caused by a combination of:

- ignorance on the part of the program official (lack of knowledge of how to get things through procurement),
- a "the rules don't apply to me" mindset, or
- a serious problem with poor performance by the contracting office.

Treatment. Determine the most likely cause of the problem. Address ignorance through training and "hand-holding" of program officials. Refer cases of malice to the appropriate investigatory body. Make the ratification process more than a rubber stamp. If program office criticisms are valid, make improving contracting office performance a priority.

The Statement of Work: The Cloud of Unknowing

Symptoms. Program offices "know what they want when they see it" but are unable to articulate in writing exactly what that is. Statements of Work (SOWs) are poorly drafted, leading to inadequate contracts and contractor performance of questionable quality.

Diagnosis. The program office may simply need to send employees to a course in SOW preparation to alleviate the symptoms. If this is not the problem, conduct further study as to what the illness is. If the problem is simply lack of talent in the program office, determine whether management can arrange for an infusion of talent from elsewhere. Failure by contracting offices to reject SOWs creates a disincentive, preventing program offices from achieving acceptable performance.

Treatment. Prescribe training for program offices in how to prepare performance-based work statements. Secure management support for additional technical resources, whether on a temporary basis (detailing skilled personnel from outside) or permanently.

Inherently Governmental: Inherently Subjective

Symptoms. Contracting regulations (FAR 7.5) do not explain clearly what an inherently governmental function is. As a result, program offices seek to contract out any and all types of services. The argument is advanced that if the contractor does not actually sign the completed work product, but rather presents the work for approval or signature by the government, it's all kosher. Contractors become indistinguishable from federal employees.

Diagnosis. The problem could be due to the fact that the program office is acting out of ignorance, malevolence, or laziness. Contracting for services is considered by some to be preferable to performance by federal employees, primarily for cost reasons. Unfortunately, no regard is given to the lack of control that contracting

entails. Instead of a proper arm's length relationship, a cozy personal services environment can easily develop if the problem is not treated.

Treatment. If the program office does not understand the rules, provide an explanation. If the program office is acting out of malevolence, refuse to issue solicitations that are for inherently governmental functions. If the program office is acting out of laziness, bring to management's attention the fact that program offices are abdicating their responsibilities by allowing contractors to rule the roost.

The appropriate long-term treatment is to change the regulations or establish more strict policies as to what is an inherently governmental function. Eliminate the ambiguities in FAR 7.5 in favor of less outsourcing, given the fact that fewer resources exist in today's government contracting workforce than were in place when the Office of Federal Procurement Policy (OFPP) Policy Letter on this subject was issued in 1992.

Nonpersonal Services: Half Truth

Symptoms. Contractor employees perform on-site in government offices doing work that is largely indistinguishable from that done by federal employees. Contracts claim to be for nonpersonal services but are administered on a personal services basis. FAR 37.104 lists six basic factors to be considered in determining whether services are personal in nature, but the regulation is vague as to how many of those factors must be present to create a prohibited personal services arrangement.

Diagnosis. The problem may be due to irresponsible SOW preparation by the program office or lax enforcement of existing regulations by the contracting office. One easily detected factor is the contractor's presence on-site in federal office buildings.

Treatment. Move contractors off-site to their own facilities whenever their presence in federal office buildings creates the appearance of personal services. Eliminate personal services elements from contracts subject to the FAR. The factors listed in the FAR are based in part on Internal Revenue Service regulations but need not be. Revise the FAR to tighten up the definition of personal services by making the presence of any two of the six listed factors sufficient to create a prohibited personal services relationship.

"Contractor employees perform on-site in government offices doing work that is largely indistinguishable from that done by federal employees."

Publicizing Upcoming Contracts: Open Mouth, Insert Foot

Symptoms. Contracting offices must wade through an excessive number of proposals, most of which are from firms with no chance of winning the award. Too many proposals become as much a problem as too few proposals because of the evaluation burden created.

Diagnosis. Synopsizing in the *Commerce Business Daily* allows any company, whether meeting the responsibility standards in FAR 9.1 or not, to request a solicitation or submit an offer. For simplified acquisitions, FAR 13.104(b) allows

contracting offices to limit the solicitation of quotations to only three firms. Common sense tells us that if evaluating lots of proposals is a burden, then we shouldn't ask for so many. The recent coverage in FAR 15.202 on using an advisory multistep source selection process can be useful, but it comes only after the world has been told that it can compete.

Treatment. Expand the "three quote rule" for simplified acquisitions to all contracts regardless of dollar value. Use the waiver authority in FAR 5.202(b) or ask Congress to make publicizing in the *Commerce Business Daily* an option, not a requirement. As noted in my recent paper (Lloyd, 1999), seek to emulate the buying behavior of private individuals, not private corporations, who would never even consider asking perfect strangers (unknown firms with no references) to compete for a job.

"Expand the "three quote rule" for simplified acquisitions to all contracts regardless of dollar value."

The Solicitation: Know What I Mean, Vern?

Symptoms. Many solicitations are incredibly long and complex, featuring excessive proposal requirements and resulting in overly long proposals that seem to take forever to evaluate. Evaluation factors and subfactors proliferate, but fail to produce improvement in source selection.

Diagnosis. This is typically a self-created problem in contracting offices. Most of the paper submitted in a proposal is worthless, amounting to empty promises that are never enforced after contract award.

Treatment. Apply the streamlining techniques developed by Vernon Edwards (1994, 1995, 1997), which include keeping the number of evaluation factors to a minimum, decreasing the size of the evaluation panel, and asking only for the least amount of information needed from offerors. Note that Edwards' approach could be made even more efficient and less mathematical by eliminating much of the number-crunching associated with scoring proposals and past performance.

Of Penalties and Liquidated Damages: Fish Four Days Old

Symptoms. Contracting officials are under the illusion that the assessment of liquidated damages for late completion of construction contracts (or downtime occurring under information technology service contracts) is "not a penalty." No one is buying this line.

Diagnosis. Liquidated damages provide a negative incentive only. Corresponding positive incentives are usually unavailable. Proper treatment of contractors to inspire outstanding effort requires a symmetrical approach with both positive and negative performance incentives.

Treatment. Seek and implement statutory or regulatory authority for bonuses and penalties. Good examples are the Department of Energy's negative fee procedures at 48 Code of Federal Regulations (CFR) 970.15404-4-1 and the bonuses and penalties law at 22 U.S.C. 4856 for overseas construction.

Contracting Automation: Call the Bunco Squad

Symptoms. Contracting offices spend inordinate amounts of time and money trying to implement comprehensive contracting automation systems that computerize all steps in the contracting process from "lust to dust," "womb to tomb," or "cradle to grave" in an integrated fashion with program, budget, and payment offices. Agencies buy "turn-key" systems that fail to start when the key is turned. New, expensive systems consistently fail or underperform. Aspirations overtake available automation tools.

As long ago as the early 1980s, federal agencies were trying to automate contracting functions without the necessary software features being available on the open market. For example, character-based systems were being advocated when clearly visual interfaces were needed. Consequently, more time was spent trying to fix poorly conceived systems than should have been devoted to such efforts. The amount of money spent on an automated system tends to be inversely related to its functionality and user friendliness.

"Bugs" evolve into "features." Workarounds and "kludge solutions" abound as contracting offices seeks to fit square contracting pegs into round automation holes. Even favorable reviews of department-wide contracting automation have confessed that significant cost reductions are unlikely to appear (Nissen, 1999).

Diagnosis. The private market for contracting technology does not always advance as quickly as federal agencies believe or desire. Determine whether wish lists of features diverge from readily available market products. Unrealistic expectations often impair critical thinking. No automation system can be all things to all people. The only meaningful progress that has been made recently in this area has been with low-budget systems that rely on the public Internet infrastructure and commonly available software instead of customized development efforts.

Treatment. Cease all "grand design" or one-size-fits-all contracting automation efforts. Do not get ahead of what the market can deliver in terms of off-the-shelf software capable of meeting agency contracting needs without customization. Rely instead on rapid development prototyping on a small scale or "proof of concept" approaches, rather than integrated systems that are bound to fail. Once small-scale pilot models are proven in practice, only roll them out to other offices if reliability can be ensured. Focus on low-cost, Internet-based systems. Do not allow budget or finance offices to dictate the needs of contracting automation systems.

"Cease all "grand design" or one-size-fits-all contracting automation efforts."

Technical Evaluation: Rogues' Gallery

Symptoms. Program office evaluations of technical proposals from offerors are poorly written and cannot withstand a protest from a losing company. Rogue evaluators pursue their own biases and agendas in skewing the technical evaluation to their favorite contractors. Contracting offices, fearing the possibility of protest,

take on the role of technical evaluators by helping redraft unartfully worded technical evaluation reports.

Diagnosis. The problem may be due to either bias on the part of evaluators or lack of training or experience in performing this function. Most federal employees have little or no experience in performing technical evaluations, which is a specialized skill in big demand.

Treatment. Reduce the size of technical evaluation panels to the minimum size possible. The FAR does not require any size at all; in fact, a single person may perform the entire technical evaluation. By keeping panels to a manageable size, and providing the opportunity for training in technical evaluation, problems of recruiting evaluators and controlling bad behavior by individual team members can be contained.

"Rogue evaluators pursue their own biases and agendas in skewing the technical evaluation to their favorite contractors."

Contractor Past Performance Evaluation: Dead Man Walking

Symptoms. Contracting offices spend an inordinate amount of time trying to obtain meaningful past performance evaluations of offerors. The results are substantial numbers of Government Accounting Office (GAO) protests from disappointed offerors, poor quality received during reference checks, and a lack of improvement in contract administration due to the effort spent in pre-award performance evaluations.

Most evaluations are neither high nor low, as references fear protests and would prefer not to be held responsible for contracting decisions of other offices or agencies. For example, take the case of a contractor with three government contracts performed in different settings: one is performed astonishingly well, one is average in quality, and another is a miserable failure.

The contracting officer is understandably unsure whether the contractor deserves a high, medium, or low past performance rating if the successful contract was performed for the contracting officer's agency. Ratings of all contractors tend to gravitate to the medium range, so as to avoid controversy (bid protests) or having one agency influence (and be blamed for) a different agency's source selection. New contractors with no past performance history never quite feel they have been treated fairly by a neutral rating. Past performance loses its value as a meaningful discriminator among contractors.

Diagnosis. Assessment of contractor performance for anything but on-time delivery under supply contracts is almost purely subjective. Despite its current enthusiasm for past performance evaluation, the Department of Defense (DoD) tried to establish a past performance system in the 1963 but abandoned it in 1971, because its costs exceeded its benefits (Edwards, 1995, pp. 2–3). Even the GAO (2000, p. 3) recently stated that past performance evaluation practices "continue to be troublesome." As readers of mutual fund prospectuses know, past performance is no assurance of future quality.

Corporations do not perform work under government contracts; the work is performed by individuals in those

corporations. To attribute outstanding past performance to a corporate entity, without regard to its specific employees on a contract, is to assume that the contractor always uses the same employees or employees who are equally talented. This is a dangerous assumption.

Treatment. If past performance must be evaluated, admit that the evaluation is subjective and rely on the level of confidence assessment rating approach advocated by Edwards (1995, 1997). Use only three rating categories: completely confident, completely not confident, and neutral. FAR 15.304(c)(3)(iv) allows agencies not to evaluate past performance where appropriate. Use this flexibility whenever the expected cost of evaluating past performance exceeds its potential benefit. Heed the lessons of the history of contractor past performance evaluation.

Formal Source Selection: Who Died and Left You Boss?

Symptoms. Large contracts are awarded based not on the independent judgment of the contracting officer but rather the preferences of a source selection authority.

Diagnosis. Some federal agencies are under the impression that large programs should not be left to the authority of the contracting officer to select the "right" contractor. When the agency head so desires, FAR 15.303(a) allows noncontracting personnel to be the ultimate authority as to who gets a contract. This regulation improperly dilutes the contracting officer's authority and subjects the agency to possible improper program influence and high-level maneuvering unrelated to the merits of the source selection.

Treatment. Revise the FAR to prohibit source selection by anyone but a contracting officer.

Federal Procurement Data System: A Day Late, A Dollar Short

Symptoms. Agencies have difficulty motivating employees to complete accurate Federal Procurement Data System (FPDS) reports (SF 279 and SF 281, or agency equivalents). The reports come at the end of the contracting process and are usually considered a paper drill. The reports are often inaccurate. Government-wide compilations of FPDS data can easily be abused by policy makers who seek to pile more legislation onto an already overloaded contracting system. Even studies claiming that the size of the government's shadow (contractor) workforce is huge (Light, 1999, p. 7) significantly understate their case because of omitted data.

"As readers of mutual fund prospectuses know, past performance is no assurance of future quality."

Diagnosis. Determine whether any of the information in the reports is useful for real-time contract management.

Treatment. Change or eliminate the system. If the reporting system does not help make contracting better, but serves only to provide macro-level numbers used for ill-considered policies, then the law requiring the system should be repealed.

Contract Changes: The Hand is Quicker than the Eye

Symptoms. Program offices desire changes to contract work statements but are never sure what will pass muster in the contracting office. Contracting offices are not sure whether contract changes requested by the program office are within the scope of the contract. The changes clause may or may not be used to accomplish the desired result.

GAO or court rulings on what constitutes a valid change are inconsistent and add fuel to the fire, sometimes leading to the paralysis of analysis before any change order occurs. Learned scholars write massive treatises on contract changes (Nash, 1991), a testament to this general sense of ambiguity. Analysts fret about the pricing problems of changing a contract because only one source provides a price proposal. Consequently, change orders are kept to a minimum and the contract loses potential effectiveness as work evolves.

"Most contracting officers have never seen a termination for default anywhere but in a textbook or a classroom."

Diagnosis. Aleister Crowley (1991) defines magic as "the science and art of causing change to occur in conformity with will." The FAR changes clause, in its various incarnations in different contract types, allows contracting officers to use their magic to make contracts evolutionary in nature rather than static relics of the past. The clause provides considerable flexibility that should be used.

Treatment. Use the changes clause to the maximum practicable extent. Only a small fraction of change orders ever makes it to GAO or the courts for dispute resolution. If pricing is expected to be a problem, make all changes bilaterally priced before the changed work begins.

Default Termination: A Problem of Invertebrate Government

Symptoms. Most contracting officers have never seen a termination for default anywhere but in a textbook or a classroom. Yet federal employees constantly complain about shoddy work by contractors.

Diagnosis. The fallacy of making default terminations a rare occurrence is that the default process itself is self-correcting. An improper default termination is easily converted to a termination for convenience. Knowing this to be true, why are contracting officers so reluctant to use the default termination as a tool? The answer is that terminating a contract for default requires backbone, an anatomical feature that seems to be in short supply.

Treatment. Terminate more contracts for default. If a default termination turns out to be in error, immediately convert to termination for convenience.

Evaluating Contracting Office Performance: The Big Nowhere

Symptoms. Agencies conduct internal assessments of contracting offices by contracting personnel in the form of procurement management reviews or balanced score card analyses. Contracting

performance does not change much as a result of these evaluations, due to their inherent limitations. Contracting offices that are "doing a bad job" continue to retain contracting authority, because no one else is available to pick up the workload; there is no serious penalty for noncompliance. Meaningful metrics are in short supply.

Diagnosis. Contracting offices that are responsive to their customers and do a good job awarding all requested contracts on time may be breaking the rules. They may not be using sound contract management in their haste to satisfy their customers. Contracting offices that fail to deliver whatever their customers want on time are roundly criticized even when they follow the rules.

Treatment. De-emphasize the measurement of contracting offices by contracting personnel. Seek other, more meaningful measures of performance. Build a reward system that genuinely encourages desired outcomes or end-states rather than simply on-time outputs. When finished, proudly retire. If unable to complete this task, continue windmill-tilting activity, but recognize that this may be the impossible dream.

Competitive Contracting Offices: License to Ill

Symptoms. Multiple contracting offices are available to award a given contract. Some of these contracting offices are funded by surcharge revenue (paid a fee based on the dollar value or number of contracts awarded). Program officials shop around to see which contracting office is the most pliable.

In their zeal to garner business, competitive contracting offices express an unhealthy willingness to bend or break the rules to get the business, and may in fact violate substantive contracting laws and regulations. A "hired gun" mentality surfaces, whereby contracting offices feel compelled to sell their services to the highest bidder to maintain a revenue stream. Contracting offices and their staffs feel beholden to program officials for their very livelihood, producing anxiety and bad judgment.

"Contracting offices should spend their time contracting, not marketing."

Diagnosis. Determine whether the contracting offices most anxious for new business are exceeding their charters. Assess the quality of their performance, within established laws and regulations. Calculate whether some contracting offices have excess capacity. If so, transfer personnel to make a more sensible distribution of workload.

Treatment. Management must scrutinize closely the movement of contracting work from one contracting office to another. Detect and resolve cases of abuse. Contracting offices should spend their time contracting, not marketing.

Acquisition Versus Procurement: Same Difference

Symptoms. Acquisition leaders fret over whether what they do (or should do) is more properly defined as acquisition (rather than procurement). Misguided contracting personnel believe their mission

extends beyond contracting to securing funding, managing programs, running technical operations, and maintaining and disposing of contracted equipment and systems.

Training companies offer courses in program management for contracting personnel. Program offices are more than willing to delegate any and all responsibilities to contracting offices whenever convenient in terms of making up for their own inadequacies. One witnesses a desire to find a fall guy in the form of a contracting office for the expected adverse publicity of a troubled project that is "programmed for failure."

"Contracting is not synonymous with program management, and contracting offices should not take on program management responsibilities."

Diagnosis. Confusion is bred from inconsistent terminology and a misplaced sense of duty. Until 1976 in DoD and 1984 in civilian agencies, the term "procurement" was considered acceptable. From 1984 on, all federal agencies have used the term "acquisition" as a result of the issuance of the FAR. Nevertheless, each agency has a statutory position of procurement executive, and the employees performing acquisition functions are often titled "procurement analysts" in both DoD and civilian agencies, working under guidance issued by the "Office of Federal Procurement Policy" or the "Director of Defense Procurement."

The term "procure" has a connotation of illicit behavior (*Oxford English Dictionary,* 1971). Outside the Beltway, the term "acquisition" is popularly regarded as either a real estate transaction or a purchase of one firm by another ("mergers and acquisitions"). The debate over which term is "correct" takes on a certain staleness, because neither is an accurate description of the work being performed.

A profession that cannot agree on its own name runs the risk of not being taken seriously. Beyond the obvious problem with terminology, for contracting professionals to feel a compulsion to perform an even broader range of activities than just contracting alone is to beg the question of whether we have "gotten contracting right" in every sense. The answer to that question is no.

Treatment. Replace the terms "acquisition" and "procurement" with "contracting." The semantic argument that instruments such as blanket purchase agreements are not "contracts" and thus must be called acquisition is simply misleading. Orders under such agreements do create contractual relationships. Cease all debate over terminology.

Contracting is not synonymous with program management, and contracting offices should not take on program management responsibilities. To do so is to prevent program management offices from living up to their responsibilities. If the day comes when contracting professionals can honestly say they do a perfect job contracting, then they can take on program management or "acquisition." That day is not likely to arrive any time soon.

Conclusion: Acquisition Reform—Take the "Con" out of "Contracting"

Some self-styled reformers assert that all we need to do to solve the ills of federal

contracting is to implement the established program of reform begun with the Federal Acquisition Streamlining Act of 1994. Regrettably, that program does little to address the many "worst practices" discussed above. A careful analysis of these pathologies can be illuminating for those who seek genuine, continuous improvement of federal contracting. When reform is proposed, one must ask whether the cure is worse than the disease, and whether our aim is on the right target.

To say, as some advocates have, that the problems of contracting can be cured by the judicious application of discretion is to fool no one. The act of giving discretion does not, by itself, make the contracting world better. Acquisition reform did not change human nature. There are those who would use additional discretion as a means of self-promotion, gaining unnecessary resources, and other damaging behavior, just as much as others would use it for substantive improvement.

If we let long-standing, systemic dysfunctions continue to exist, while claiming that our best practices have reformed contracting, we will fall prey to another form of the confidence game. The victim of the confidence game refuses to believe that he is being relieved of his money and dignity, but an ignominious fate awaits him every time. As Maurer (1940, p. 103) puts it: "To expect a mark to enter into a con game, take the bait, and then, by sheer reason, analyze the situation and see it as a swindle, is simply asking too much." Keen judgment and an eye toward good health dictate that we learn the lessons of continuing "worst practices" and resist being conned into a false sense of security about the real state of federal contracting.

The problems I have cited here are not particularly easy to remedy, if they can be solved at all. Working on their solution will not be a glamorous or high visibility assignment. Perhaps we can claim some measure of success in enhancing federal contracting in recent years. The challenge now is not simply to implement a predetermined, 6-year old program of reform but rather to avoid the temptation to boast that all needed changes have been addressed. Herd behavior and complacency are the enemies of true reform. We should redouble our efforts to treat the more persistent maladies that plague federal contracting, if we value candor more than conformity.

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The views expressed in this paper are solely the author's and do not necessarily represent those of any U.S. government agency.

References

Bennis, W. G. (1970). *American bureaucracy.* New Brunswick, NJ: Transaction Books.

Crowley, A. (1991). *Magick in theory and practice.* Secaucus, NJ: Castle Books.

Downs, A. (1967). *Inside bureaucracy.* Boston: Little, Brown.

Edwards, V. (1994). Streamlining Source Selection by Improving the Quality of Evaluation Factors. 8 Nash & Cibinic Report 56. Washington, DC: Federal Publications, Inc.

Edwards, V. (1995). *How to evaluate past performance: A best-value approach.* Washington, DC: George Washington University.

Edwards, V. (1997). A 60-day source selection process for service procurements. *The Federal Acquisition Practitioner 1*(1), 4–6.

General Accounting Office (GAO). (2000). *GAO bid protest overview: fiscal year 1999.* Washington, DC: GAO.

Hummel, R. H. (1982). *The bureaucratic experience.* New York: St. Martin's Press.

Kelman, S. (1990). *Procurement and public management: The fear of discretion and the quality of government performance.* Washington, DC: AEI Press.

Klein, G. (1998). *Sources of power: How people make decisions.* Cambridge, MA: MIT Press.

Light, P. C. (1999). *The true size of government.* Washington, DC: Brookings.

Lloyd, R. (1999). Acquisition and individualism. *Proceedings of the 1999 Acquisition Research Symposium* (pp. 349–363). Washington, DC: DSMC/NCMA.

Maurer, D. W. (1940). *The big con.* New York: Anchor Books.

Muczyk, J. P. (1998, Summer). Generating needed modernization funds: Streamlining the bureaucracy—Not outsourcing and privatizing—is the best solution. *Acquisition Review Quarterly,* 317–332.

Nash, R. (1991). *Changes.* Washington, DC: Federal Publications, Inc.

Nissen, M. E. (1999, Winter). SPS and beyond: Innovative acquisition through intelligent electronic contracting. *Acquisition Review Quarterly,* 383–394.

Oxford English Dictionary (1971). Definition of "procure." Volume II, p. 1418.

OPINION

MAINTAINING THE GOVERNMENT'S ABILITY TO BUY SMART

Carolyn Wong, Ph.D., Kenneth Horn, Ph.D., Elliot Axelband, Ph.D., and Paul Steinberg, Ph.D.

Today, the Department of Defense possesses a competent "smart buyer" (SB) capability. But unless corrective measures are soon taken, the effect of downsizing the federal government workforce may undermine future SB capability. Three measures will prevent this from happening: the Department of Defense must establish and maintain collaborative research environments; it must try to ensure that work environments encourage direct and open communications among the players; and it must maintain a talented technical staff of scientists and engineers by exploiting the full range of recruiting tools and implementing career development opportunities.

Today the Department of Defense's (DoD's) "smart buyer" (SB) capability—its in-house technical expertise to stand up to its industry counterparts when dealing with technical issues of the conceptual design, research and development (R&D), and procurement of new military systems—is sufficient. Although the DoD's SB capability involves the integrated efforts of many disciplines within each Service (including those with technological, engineering, legal, procurement, management, and funding expertise), this article focuses only on technical expertise, defined as technological, scientific, engineering, and mathematical skills. Unless otherwise noted, SB capability will be used as shorthand for only the technical element of an overall SB capability.

The technical element is provided mainly by the technical staff at each Service's R&D organizations. Their expertise helps the Services' concept and materiel developers conceive, formulate, and execute materiel programs. In the context of this article, the term "smart buyers" (SBs) refers to in-house technical personnel who, by contributing their individual specialized expertise, collectively represent a smart buyer capability.

The DoD must maintain an SB capability because technological superiority is a mainstay of this nation's overall defense

strategy. The Army's case illustrates technology's lead role in our nation's defense. The Army is relying more and more on advanced technology to modernize its force structure. For example, the Army XXI force will evolve combat through enhanced battlefield awareness via information technology. The Army After Next (AAN) force will go farther and be a revolutionary, technology-driven future force. Planning for AAN is the major driver of Army science and technology (S&T), and the Army needs knowledgeable government scientists and engineers (S&Es) who are closely attuned to state-of-the-art developments if it is to fully exploit the technology advances that AAN will require.

The government has been keenly aware of the importance of the SB function for many years. The landmark 1991 Federal Advisory Commission listed 15 principal study findings. The first and foremost of those findings states that the mission of defense laboratories is to provide the technical expertise that enables the Services to be smart buyers and users of new and improved weapon systems and support capabilities.[1] In addition, our recent survey of acquisition workers within the Army and opinions collected from industry representatives both support the position that a capable SB function is vital and must be maintained.

Shrinking Personnel Pool Threatens SB

The SB problem that will soon face the DoD stems from a shrinking pool of civilian S&Es. Since the SB function is an inherently governmental function, its capability is dictated by the size (and quality) of the government civilian workforce.[2] Civilian S&Es who help perform the SB function make up a large portion of the DoD's civilian workforce.

Currently, there is a trend toward downsizing all government civilians, including S&Es. For example, in 1991, the total number of S&Es in the Army was 16,600. By the end of 1998, the number had decreased to 14,330.[3] The projections for the future are for even lower levels.[4] These reductions are the result of mandated personnel caps and are mirrored by similar S&E reductions in the other Services. These S&E personnel cuts run counter to maintaining an adequate SB capability: They can result in personnel turbulence, loss of technical expertise or critical mass in technology areas, poor staff morale, and fragmented work. Unfortunately, the DoD has to assume that these cuts will continue. The National Defense Authorization Act for Fiscal Year 2000 specifies further reductions for fiscal years 2000 and 2001.[5]

This article draws on current and ongoing research to identify how changes and efficiencies in the SB capability and workforce can counteract the effects of fewer personnel; it then makes some recommendations to improve the current situation.

What Is Needed to Maintain and Strengthen SB Capability?

Before we can recommend specific corrective actions, we need to discuss what is needed to maintain and strengthen the DoD's SB capability. Our SB research over the past several years indicates that three ingredients are required to provide a good SB capability:

- a collaborative research environment;
- communication among SBs and concept and materiel developers; and
- a cadre of talented and trained technical staff.

In this section we will summarize our research findings on each of these ingredients and discuss their implications for the SB problem.

Collaborative Research Environment

S&Es must be knowledgeable about all aspects of their rapidly changing technological fields. This means knowing what is happening in their own laboratories as well as in those of other Service and government agencies, academia, and industry. A collaborative research environment essentially forces the S&Es to be aware of what is going on outside their own organizations.

Support for this important observation is provided by studies on performing collaborative research with nontraditional military suppliers and on other forms of collaborating and partnering.[6] This point is also acknowledged in government studies of military laboratories. A good example is the National Research Council's recent assessment of the Army Research Laboratory (ARL).[7] This study notes that to perform its mission, ARL must have professional staff members aware of research outside its organization. Insularity from the outside hurts its ability to support the Army with state-of-the-art technical expertise.

All the studies are in general agreement that wide exposure to the development of technologies outside one's own organization is a key ingredient for keeping current about technological advances and honing one's SB skills. This outside exposure can be obtained by conducting collaborative efforts with other government laboratories, academic institutions, and private industry.

Although each Service is currently performing some valuable collaborative efforts with industry through cooperative research and development agreements and cooperative agreements, more opportunities exist for joint Service-government a-gency collaborations and collaborations with industry. We believe the key to forming these new collaborations lies in exploiting acquisition reform initiatives. These initiatives include establishing joint ventures with industry, using "other transaction" contractual instruments, establishing recoupment arrangements when spinoff commercial entities are formed, requiring cost-sharing with in-dustry, and exploiting revenue-generation opportunities using their infrastructure and intellectual property assets.

"Our research has shown that industry is willing to partner with the government if a collaborative atmosphere is maintained."

Our research has shown that industry is willing to partner with the government if a collaborative atmosphere is maintained. A major obstacle to collaboration with industry seems to be the Services' reluctance to embrace these new acquisition reform initiatives. To break down this resistance, cultural barriers need to be removed. Education and training must be provided to all laboratory personnel—S&Es, legal counsel, contracting, and

management. The Services must educate their work-forces about the benefits of the acquisition reform initiatives much in the way they have handled military specifications and integrated product teams (IPTs). In particular, the Services must place emphasis on the various initiatives currently available and show how they can be used to form collaborative research efforts.

"Although proximity is usually desirable, what is more important is the directness of the reporting channels."

Communication Among Smart Buyers and Concept and Materiel Developers

Each Service's concept and materiel developers must have access to the SBs. It does not do any good for the Army, Navy, or Air Force to have the brightest and most knowledgeable SBs in the government if their talents are not used by the concept and materiel developers. To be effectively used, the SBs must be closely coupled to the Service's users with two-way communications in place.[8]

The Service laboratories need to provide the SB function to the concept developers and complement the technical expertise of the materiel developers. While generally effective, in some cases the SB communication channels pass across different command structures (e.g., going up one command ladder, across to another, and down to the SBs). In these cases, more direct communication channels are desirable. This does not necessarily imply that physical proximity is needed. Although proximity is usually desirable, what is more important is the directness of the reporting channels.

The usefulness of the SB information, however, is not determined solely by whether or not direct communications channels exist. Equally important is how effectively SBs are being used. Effectiveness is dictated by many factors, including the organizational relationships between the SBs and the users, the goals and objectives of the laboratory management, and the users' specific needs.

Our research has addressed organizational restructuring that enhances communication channels and effective information exchange. In some cases, new organizational reporting chains are needed, while in other cases, streamlined communication channels appear sufficient.

Cadre of Talented Technical Staff

The third ingredient to providing a good SB capability involves people. Each Service must have a talented technical staff of S&Es available to maintain a competent SB capability. This means each Service needs to acquire, sustain, train, and develop technically competent S&Es and also be able to separate less productive staff. These tasks are complex and especially challenging in a period of downsizing.

Because the civilian S&E personnel issues facing the Services are multifaceted, we will first discuss some of the underlying problems and then describe the analyses we have performed to help better understand them. Our research focused on the Army, but our insights are applicable to all the Services.

Some Army personnel issues. The civilian personnel issues facing the Army

are numerous, as illustrated by the staffing statistics of S&Es at two Army laboratories. Figure 1 shows that at ARL, the population of S&Es is bimodal in age distribution. The first peak occurs around age 36, with very few staff members under 30. This suggests that few new S&Es are being hired after college graduation, which means there is a small "feeder group." Also, as the figure indicates, the distribution of grade levels at ARL has bunched at General Schedule (GS) grade 13. Finally, as shown in the bottom of the figure, approximately 65 percent of the ARL separations in the period fiscal year 1993 to fiscal year 1997 were voluntary (including retirements), while only 8 percent were involuntary (the result of individual removals or reductions-in-force). This suggests that many of ARL's voluntary departures may have included highly qualified and talented S&Es.

The Army Research, Development, and Engineering Centers (RDECs) are facing their own personnel problems. Data for the Tank-Automotive RDEC (TARDEC) are shown in Figure 2.

While the S&Es at the TARDEC and ARL have different age distributions, both laboratories are experiencing a bunching of GS grade levels, and most separations are voluntary. The age distribution of S&Es at the TARDEC shows a similar bimodal shape, although the distribution is not as pronounced as ARL's. In addition, unlike at ARL, at TARDEC many of the S&Es are young enough that a reasonably-sized feeder group (S&Es from 21–34 years of age) exists. This is partly because of TARDEC's successful cooperative program

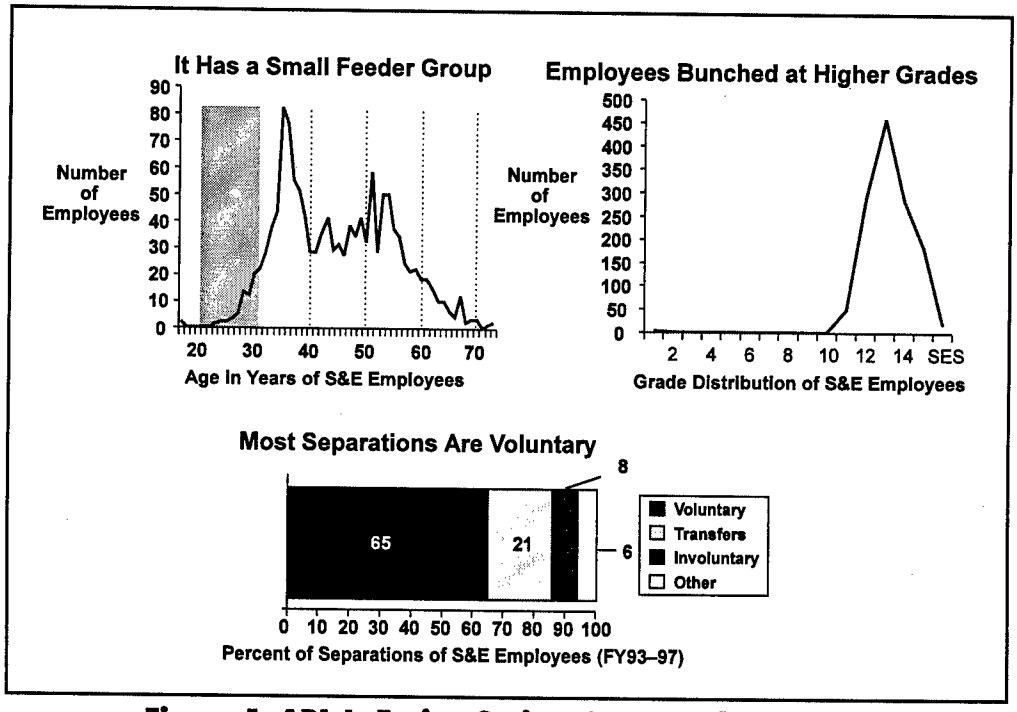

Figure 1. ARL Is Facing Serious Personnel Problems

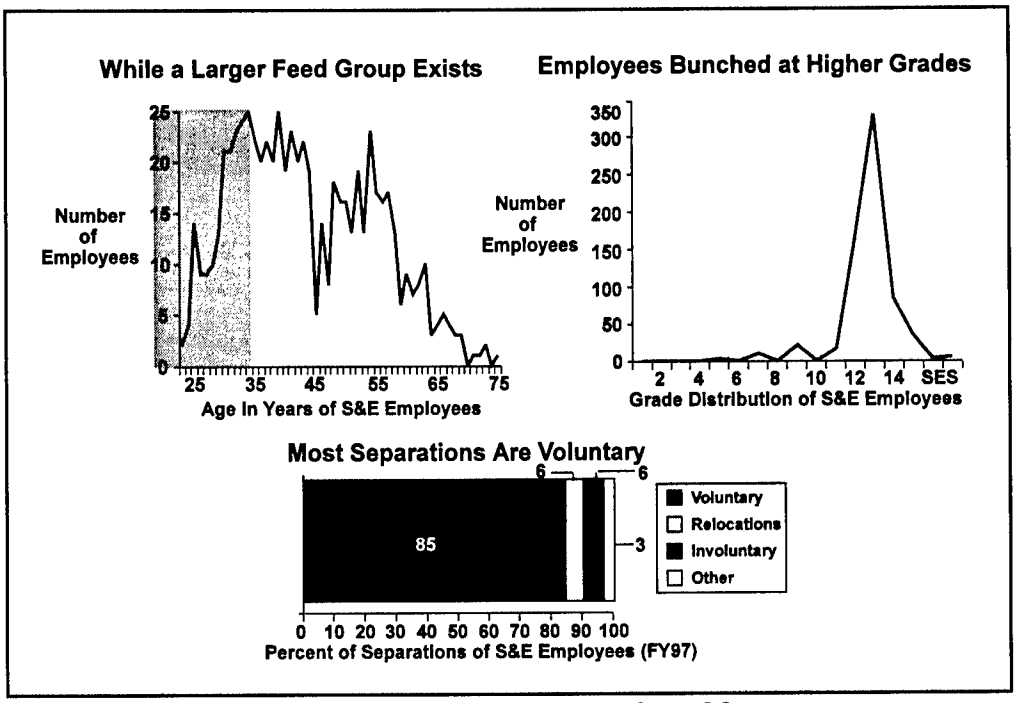

Figure 2. RDECs Face Related Problems

and the TARDEC University. Like ARL, however, there is a bunching at the GS–13 level, and the number of voluntary separations is very large. Personnel out-briefs at the TARDEC suggest that many S&Es are leaving because positions with greater responsibility and higher salaries are currently available in industry.

Analysis of personnel reform initiatives. To gain a better understanding of the Army's S&E personnel situation, we performed two types of analyses. First, we assessed the potential of the various personnel reform initiatives currently being tested within the government that are designed to help alleviate some of these civilian personnel problems. Some of these initiatives are part of the new personnel demonstrations authorized under the National Defense Authorization Act. Others are techniques and instruments that have already been approved but are infrequently used by laboratory managers (e.g., recruitment or relocation bonuses).

New initiatives are also being examined as part of the DoD Acquisition Workforce Personnel Demonstration Project and the Army S&T Reinvention Laboratories demonstrations. In addition to these congressionally authorized demonstrations, other personnel programs have recently been approved. All in all, there are about 50 personnel reform initiatives in the hopper.

We assessed the effectiveness of these initiatives, grouping them into four generic force-shaping areas: acquire, sustain, train and develop, and separate. We then evaluated each initiative by assessing how well it addressed specific concerns. For

example, in the sustain area, we considered whether the various initiatives would:

- stop voluntary departures of experienced personnel;
- reduce the industry pay gap;
- stop GS grade-level bunching;
- increase morale; and
- improve flexibility and prioritization in work assignments.

Based on our analysis, we have found effective personnel reform initiatives in all four force-shaping areas. Some of the more important initiatives in each area relevant to civilian S&Es are shown in Table 1.

Analysis of SB Development and Training

The second analysis we performed specifically addressed the training of SBs: In particular, we sought to find out what S&Es must do to become good SBs. We performed this analysis by surveying Army acquisition staff members who either performed the SB function or used the SB products. Fifty-five staff members were surveyed from a half-dozen Army R&D organizations; they included program managers, ARL S&Es, and RDECs S&Es. Management selected these personnel as being either examples of good SBs or knowledgeable about what it takes to be a good one. The survey findings were supplemented with reviews of past studies, telephone interviews of selected staff from ARL and some RDECs, and transcripts

Table 1. Important Personnel Reform Initiatives

Force Shaping Area	Initiative
Acquire	Special pay scale Recruitment bonus Relocation bonus Co-op/intern programs
Sustain	Retention allowance Pay broadbanding[a]
Train and Develop	Fellowship programs Postdoctoral studies
Separate	Voluntary separation incentives Voluntary early retirement Voluntary emeritus program

[a] Broadbanding refers to a situation where several GS grades are combined into a band with no steps, meaning that movement through a band is tied to performance, not just seniority.

from recent Army Materiel Command (AMC)-conducted interviews of selected acquisition personnel in the Army, the Office of the Secretary of the Defense, and industry.[9]

Respondents were asked, for example, to "Please rank the factors contributing to the quality in your smart-buyer personnel: (education, recent experience as a performer of research, general engineering experience, and industrial experience." Respondents were asked to list other factors; none did. Thus we conclude that all the important factors were considered in the survey.

Figure 3 is a summary of the responses to this question. Surprisingly, no one factor clearly stood out as being the most important to maintaining one's SB capability. A general engineering experience is the most important of the four factors, while industrial experience is the least important. Recent hands-on research and education fall somewhere in between.

These results suggest that to train civilian S&Es to be good SBs, the Service laboratories must provide opportunities for staff members to engage in each activity. In some cases, changes in the way research is performed at a laboratory will help satisfy the SB training needs. For example, by performing more collaborative research (as discussed above), S&Es will be able to gain industrial experience through assignments with industrial teams. Off-site exchange programs with industry and exposure to industrial operations and research practices can also provide valuable industrial experience.

S&Es must also be given opportunities to perform hands-on research. While there is increased pressure today to outsource more and more government activities,

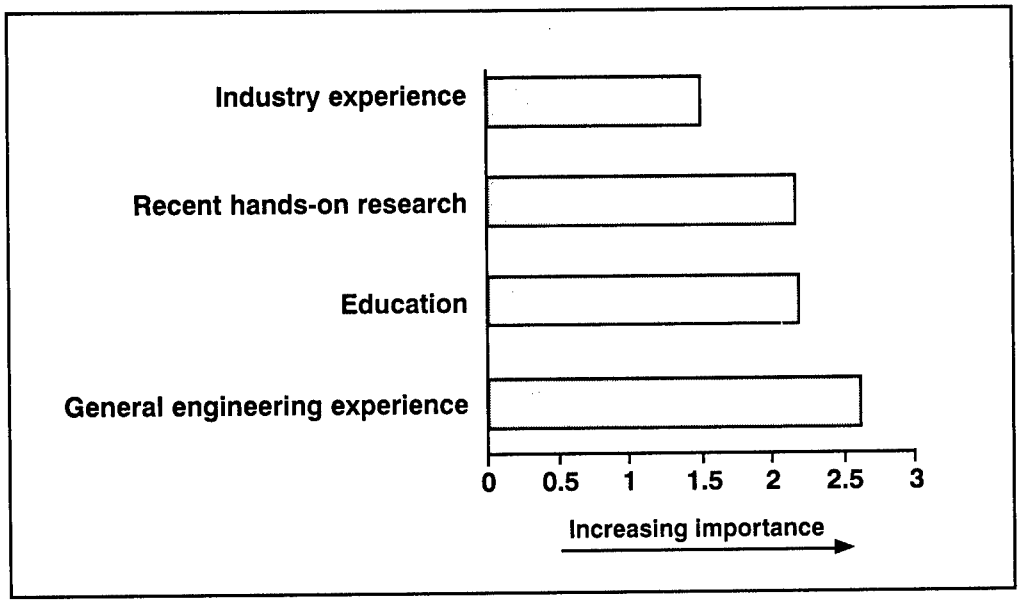

Figure 3.
Relative Importance of Key Factors in Maintaining SB Capability

including more of the Service's science and technology, if carried too far this practice could hurt SB capability by reducing opportunities for S&Es to gain hands-on research experience. For example, the AMC already outsources about two-thirds of its science and technology budget. If outsourcing of science and technology continues and is overdone or done unwisely, SB capability will likely degrade. Instead of keeping up with state-of-the-art technology developments through performing hands-on research, the government S&Es will be relegated to the role of monitoring the contractor's work (and steadily losing the technical capability to perform the work) and performing other nonresearch-related administrative and oversight functions.

The importance of education means that efforts are needed to seek top-notch technical talent from ranking colleges and universities using all the available recruiting tools. Intern and co-op programs (as shown in Table 1) also provide a mechanism for obtaining qualified recruits from local or regional colleges. S&Es should also be given the opportunity and the encouragement to obtain advanced degrees and take sabbaticals with other Service and government agency laboratories, universities, and industry.

With regard to general engineering experience, S&Es should be given career-enhancing work assignments to expand their engineering experiences. Such assignments can be a part of each S&E's career plan.

Another issue addressed in our survey was the recognition of outstanding SB performance. Based on the survey results, we believe the Army laboratories may inadvertently be sending conflicting messages about how they value SBs. While smart buyer activities are recognized as important because they promote good relations with the customers and keep the laboratory recognized as relevant, it is not apparent that the SB efforts of the Army's S&Es are always adequately acknowledged.

A cursory examination of achievement award programs suggests that awards are given for performing publishable experimental and theoretical research. For example, of the 27 Army R&D Achievement Awards for 1996, none were given for performing an outstanding job as an SB. Similarly, an assessment of the Communications-Electronics Command (CECOM) awards for the same year showed that none of the 13 awards was given for exceptional SB performance.

"The importance of education means that efforts are needed to seek top-notch technical talent from ranking colleges and universities using all the available recruiting tools."

What Can Be Done to Improve the Situation?

Our discussion shows that a work environment that includes collaborative efforts with all segments of the government and industry fosters the awareness and exposure to technological advancements that S&Es need to maintain and develop their smart-buying skills. In addition, a working atmosphere that encourages open and direct communications among the concept and materiel developers allows both SBs and developers to hone

their skills and effectively use each other's talents to benefit the nation's defense. While a collaborative work environment that encourages direct communications would be desirable under any circumstances, its existence is essential when personnel ceilings, recruiting difficulties, and fierce competition for S&Es from the private sector threaten to degrade the DoD's SB capability.

The DoD must establish a strategic approach to help mitigate the effects on its SB capability of government downsizing, recruiting impediments, and rivalry for S&Es. Based on our analysis and ongoing research in this area, we recommend that the DoD's approach include the following elements.

"Work environments must ensure that SBs, concept developers, and materiel developers can easily communicate with one another."

Establish work environments that contain substantial amounts of collaborative efforts. R&D organizations should be encouraged to perform more collaborative research with other Services, government agencies, and private industry. This will entail implementing new ways of doing business using acquisition reform initiatives that permit leveraging the other Services and government agencies and partnering with industry. Collaborations will help guarantee that the technical staffs involved in the smart-buying process are aware of what is going on elsewhere in their technical fields. Such a collaborative atmosphere, along with techniques such as the use of postdoctoral scholars and Intergovernmental Personnel Act (IPA) employees, will allow SBs to increase their technical competence and currency.

Each Service must take several steps to effectively expand its collaborative research efforts with industry.[10] First, each Service must identify technology areas where collaborative efforts overlap with industry (e.g., align Army technological objectives with the company's strategic goals). Next, the Services must proactively seek industrial partners through aggressive "marketing" techniques that include understanding the company's market niche and strategic goals. Finally, the Services must be willing to be flexible in negotiating with candidate industrial partners (e.g., minimizing burdensome oversight and regulations).

Ensure that work environments encourage direct and open communications among SBs, concept developers, and materiel developers. Military strategists and program managers or program executive officers (PEOs), along with the military R&D organizations, should work together to ensure open and direct communications channels. Work environments must ensure that SBs, concept developers, and materiel developers can easily communicate with one another. Such efforts might entail developing organizational realignments that provide close two-way SB communications. Emphasis should be placed on eliminating complicated mazes of reporting structures that hamper access.

Maintain a cadre of talented technical staff. The Services must successfully accomplish three tasks to maintain a cadre of talented technical staff. First, the Services should exploit the full range of recruiting tools to attract the most promising candidates. Personnel reform initiatives

include a number of tools available for attracting these individuals. Intern programs—such as the Career Related Experience Science and Technology (CREST) program, which provides summer and part-time employment to undergraduate and graduate students, the Student Temporary Employment Program (STEP), and the Student Career Experience Program (SCEP)—appear to be successful and should be continued. Other tools, such as recruitment bonuses, have rarely been tried, and some pilot trials with these tools will help establish their role in successful recruiting practices.

Second, the Services should implement career development opportunities to ensure that employees have all the skills to perform the SB function. This means providing all S&Es with opportunities to acquire the four proficiencies necessary to becoming a good SB. In particular, the Services must provide opportunities for S&Es to acquire industry experience, perhaps through industry exchange programs and well-designed collaborative projects.

S&Es must also be able to devote a portion of their time to performing hands-on research. To ensure ample opportunities to gain this experience, the Services must devise criteria for determining what and how much R&D should be kept in-house and what can be outsourced. S&Es must be able to acquire the required level of education in their fields. The Services and their workers will mutually benefit if the Services encourage and support education at the nation's top universities. Finally, S&Es need general engineering experience. The Services can ensure this requirement is met through a well-planned series of work assignments.

Third, the Services must create influences that will encourage talented and promising SBs to stay. The Services must ensure that career advancement opportunities are available to its S&Es. Reform initiatives such as pay broadbanding will help, but more innovations may be needed. In addition, the Services must ensure that tangible recognition of good smart buying adequately reflects the importance of this capability. For example, criteria for salary increases, promotions, and awards may have to be defined, established, or revised to better tie outstanding performance of smart buying to these rewards.

If these actions are implemented, then the DoD's SB capability will not only be maintained, it will be strengthened, and the nation will benefit.

AUTHORS' NOTE

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ENDNOTES

1. Federal Advisory Commission on Consolidation and Conversion of Defense Research and Development Laboratories. (1991, September). *Report to the Secretary of Defense.* Washington, DC: Author.

2. For a variety of reasons, the SB function should not be outsourced. For example, it would create conflicts of interest, result in a loss of user understanding or institutional memory, result in torn loyalties between satisfying a contractor's financial goals and the government's materiel needs, or lead to proprietary concerns by other contractors.

3. Career Program 16 (engineers and scientists in nonconstruction), data provided by Office of the Deputy Assistant Secretary of the Army (Civilian Personnel Policy).

4. For example, the S&Es at Army Materiel Command (AMC) are likely candidates for future cuts. The AMC response to the Defense Reform Initiative Directive No. 20 (DRID No. 20) has indicated that 73 percent of the S&Es at AMC are listed as "subject to review," meaning that their jobs could be replaced with contracted workers. For consistency across major commands, the AMC position was changed by the Department of the Army to 15 percent; however, the Office of the Secretary of Defense may change this percentage again to achieve leveling across the Services.

5. Section 922, "Defense Acquisition Workforce Reductions," of the National Defense Authorization Act for Fiscal Year 2000 specifies reductions in the Department of Defense acquisition workforce. SBs, and S&Es in particular, are part of that workforce. Although the law does not specify the exact number of S&E positions to be eliminated, it is reasonable to assume that some of the reductions will be S&Es. Similar indications of S&E reductions reside in AMC's plans to eliminate 10,000 civilian jobs in the next several years.

6. Horn, K. et al. (1997). *Performing collaborative research with nontraditional military suppliers* (Report MR-830-A). Santa Monica, CA: RAND; Wong, C. (1998). *An analysis of collaborative research opportunities for the Army* (Report MR-675-A). Santa Monica, CA: RAND; Chang, I. et al. (1999). *Use of public-private partnerships to meet future Army needs* (Report MR-997-A). Santa Monica, CA: RAND.

7. Army Research Laboratory Technical Assessment Board, Commission on Physical Sciences, Mathematics and Applications, National Research Council. (1998). *1997 Assessment of the Army Research Laboratory.* Washington, DC: National Academy Press. (Also summarized in *Defense Week,* 1998[February 23], 15.)

8. This finding is a fundamental tenet of communications theory (see, e.g., Burke, K. [1969]. *A rhetoric of motives.* University of California Press, p. 39.) We have addressed some of the associated issues in Chang, I. et al. (1999). *Use of public-private partnerships to meet future Army needs* (Report MR-997-A). Santa Monica, CA: RAND.

9. *Assuring adequate Army capability in science and technology.* (1998, July). Army Materiel Command (video format).

10. As a result of interviews with leading-edge information technology (IT) companies, we have gained insight into what is required to attract nontraditional military suppliers, such as IT companies, to work for the government. (See K. Horn, et al. [1997]. *Performing collaborative research with nontraditional military suppliers* (Report MR-830-A). Santa Monica, CA: RAND.

BIBLIOGRAPHY

Army Research Laboratory Technical Assessment Board, Commission on Physical Sciences, Mathematics and Applications, National Research Council. (1998). *1997 Assessment of the Army Research Laboratory.* Washington, DC: National Academy Press.

Brown, A. (1998, August). *Reinventing government research and development: A status report on management initiatives and reinvention efforts at the Army Research Laboratory* (ARL-SR-57). Adelphi, MD: Army Research Laboratory.

Chang, I., et al. (1999). *Use of public-private partnerships to meet future Army needs* (Report MR-997-A). Santa Monica, CA: RAND.

Committee on Alternative Futures for the Army Research Laboratory Board on Army Science and Technology Commission on Engineering and Technical Systems. (1994). *The Army Research Laboratory alternative organizational and management options.* Washington, DC: National Research Council.

Crawford, M. (1998, February 23). NRC identifies weaknesses in Army Research Laboratory. *Defense Week,* 15.

Defense acquisition organizations: Status of workforce reductions (GAO/NSIAD-98-161). (1998, June). Washington, DC: U.S. Government Accounting Office.

Federal Advisory Commission on Consolidation and Conversion of Defense Research and Development Laboratories. (1991, September). *Report to the Secretary of Defense.* Washington, DC: Author.

Horn, K., et al. (1997, November-December). Conducting collaborative research with nontraditional suppliers. *Army RD&A,* pp. 39–41.

Horn, K., et al. (1997). *Performing collaborative research with nontraditional military suppliers* (Report MR-830-A). Santa Monica, CA: RAND.

Horn, K., et al. (1999). *Maintaining the Army's "smart buyer" capability in a period of downsizing* (White Paper WP-120). Santa Monica, CA: RAND.

National Defense Authorization Act for Fiscal Year 2000. Pub. L. No. 106-65.

Office of the Under Secretary of Defense for Acquisition and Technology. (1998, June). *Report of the Defense Science Board (DSB) Task Force on the defense science and technology base for the 21st century.* Washington, DC: Author.

Secretary of Defense. (1998, April). *Report to Congress: Actions to accelerate the movement to the new workforce vision.* Washington, DC: Author.

Wong, C. (1998). *An analysis of collaborative research opportunities for the Army* (Report MR-675-A). Santa Monica, CA: RAND.

Wong, C., et al. (1998, Fall). An approach for efficiently managing DoD R&D portfolios. *Acquisition Review Quarterly, 5*(4), 339–356.

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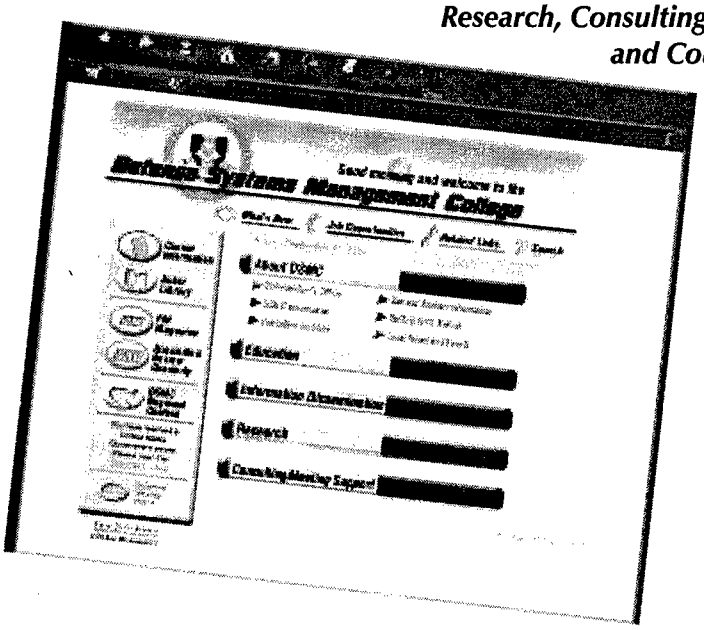

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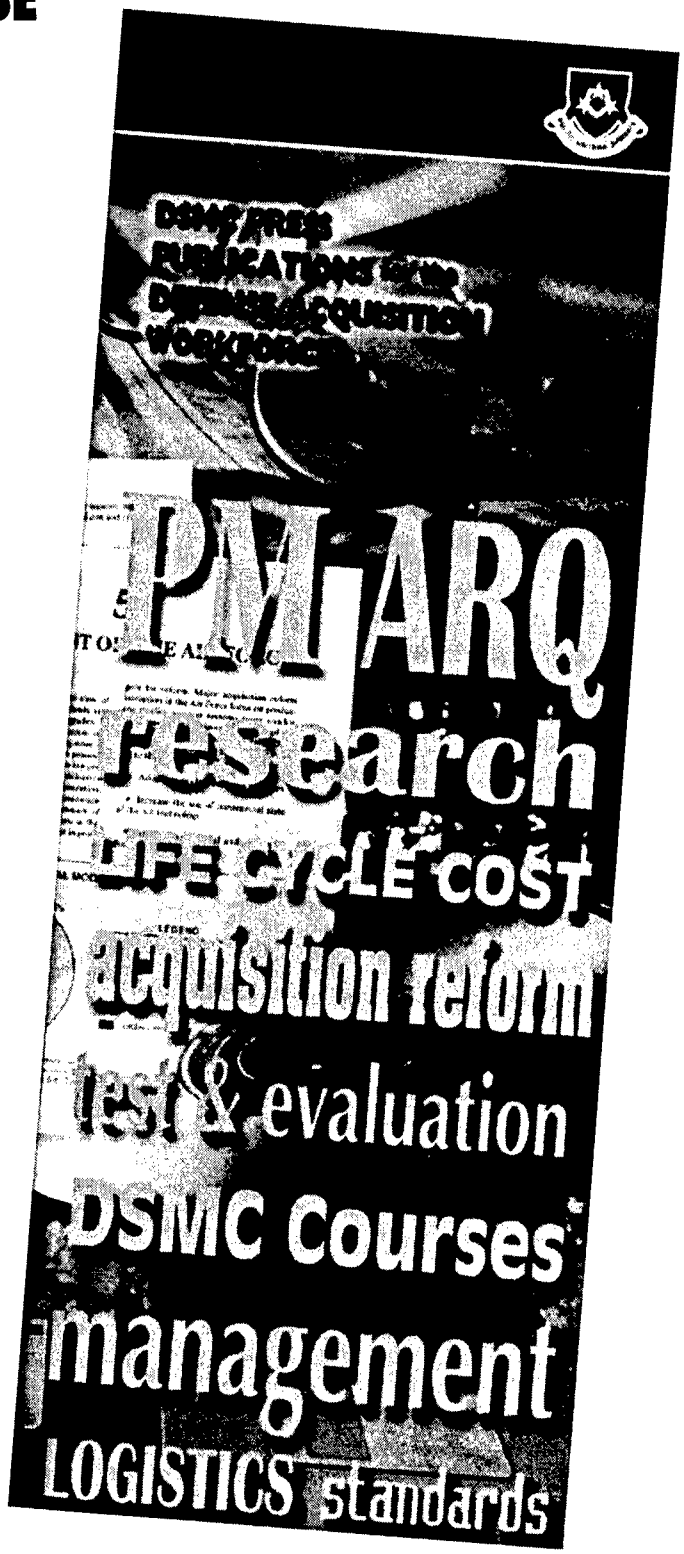

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